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AIR&SPACE

Smithsonian

December 2002/January 2003
Volume 17 • Number 5

FEATURES

SPECIAL SECTION: SEAPLANES

(About as close as we'll ever get to a swimsuit issue.)

Cover: *In Tom Reynolds' photo, the Lockheed Martin X-35A trails a Boeing KC-135 tanker, but in the Joint Strike Fighter competition, Lockheed's aircraft was second to none.*

DEPARTMENTS

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The Mars Channel

NASA is embarked on an ambitious program to study the enigmatic planet Mars, and researchers at the National Air and Space Museum's Center for Earth and Planetary Studies (CEPS) want to take Museum visitors along for the ride. Through their involvement in upcoming Mars missions, John Grant and Bruce Campbell will help to ensure that the excitement of exploring the Red Planet will be up close and personal.

The next NASA mission to Mars, to be launched in 2003, will carry twin Mars Exploration Rovers. Grant co-chairs the group charged with finding the best landing sites for the rovers and is also a member of the rover science team. During the mission, he will help evaluate the geology along the rovers' trail, and will try to identify the processes responsible for shaping the landscape. The project's ultimate goal is to determine the climate and geologic history of two sites on Mars where conditions may once have been favorable for the development of life.

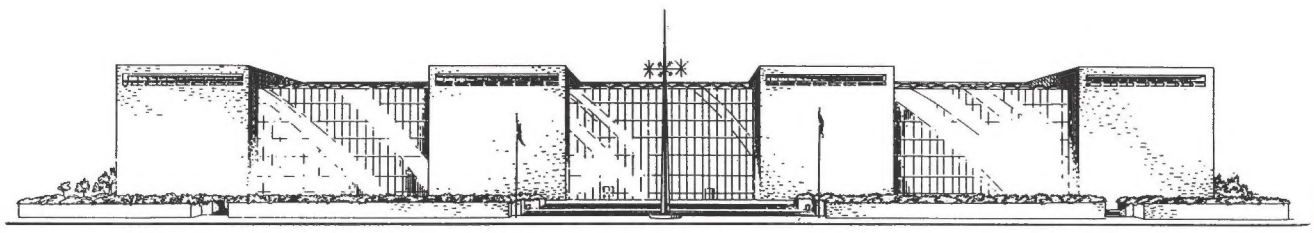
In 2005, NASA will launch the ambitious Mars Reconnaissance Orbiter. This large satellite will use advanced remote-sensing instruments to provide new views of Mars. Grant is a member of the science team for the satellite's High-Resolution Imaging Science Experiment (HiRISE) camera, which will capture images of the surface in fantastic detail—even objects slightly larger than a beach ball. Says Grant: "You can think of it as the next best thing to being there."

Campbell is a team member for the orbiter's Shallow Radar (SHARAD) sounder, which will use radar waves to probe as deep as one kilometer (roughly two-thirds of a mile) beneath the surface. SHARAD will search for rock layers and ancient channels carved by water—and perhaps identify pockets of ice.

Grant and Campbell won't be the only ones to get a look at the data from the two missions. The Museum will display images from Mars in near-real time; look for an announcement in a future "In the Museum" for more about this activity. While NASA scientists and CEPS researchers analyze the images, Museum visitors will be able to participate in the excitement of discovery. Lectures, gallery displays, theater projections, and frequent updates on the Museum's Web site will allow everyone to join in the exploration of Mars. If you can't wait for the pictures and data from the 2003 and 2005 missions, a sneak preview of what's to come is on display in the Exploring the Planets gallery. The gallery now presents live images from the Thermal Emission Imaging System (THEMIS) instrument on the 2001 Mars Odyssey probe, generously provided by researchers at Arizona State University and NASA's Jet Propulsion Laboratory in Pasadena, California.

In the exploration of our solar system, Mars is the next great frontier, and the coming expeditions to this fascinating planet should provide quite a show. The National Air and Space Museum will continue to provide a front row seat for all of our visitors.

—J.R. Dailey is the director of the National Air and Space Museum.



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LETTERS

Starfighter to MiGs: Bring it On

According to "How the F-104 Was Born," the sidebar to "Sky High" (Oct./Nov. 2002), the F-104 "never got a chance to tangle with any MiGs." On January 13, 1967, pilots in four Republic of China (Nationalist) F-104Gs engaged MiG-19s of the People's Republic of China. Major Shih-Lin Hu and Captain Bei-Po Shih each shot down a MiG.

Jack Hwang
Sunnyvale, California

"Sky High" was well written and covered both the good and bad traits of the F-104. I was the first military pilot to fly the XF-104 after Tony LeVier's first flight, which I chased in an F-86. It was my test program. I spun the airplane a lot.

The article's writer, George Marrett, was an example of the outstanding pilots who attended the Aerospace Research Pilot's School in preparing for duty in space with the Air Force's X-20 Dyna Soar and Manned Orbiting Laboratory programs. The move by the administration to keep space for peaceful purposes ended all of the Air Force's plans for space. NASA took over the mission, and the Russians moved into the void. NASA did pick up about 26 graduates of our school, and they later flew in the Mercury, Gemini, Apollo, and shuttle programs.

I have to correct the statement that the F-104 "never got a chance to tangle with any MiGs, but if it had, it would have left them in its contrails." From 1971 to 1973, I was the U.S. defense representative to Pakistan, assisting the Pakistani air force in the war with India. We were flying B-57s, Mirage 5s, F-86s, MiG-19s, and F-104As. The Indians were flying Su-7s, MiG-21Js, and other aircraft. Two of our F-104As tried to turn with the Mig-21Js and were shot down with guns.

—Brigadier General Charles E. Yeager
U.S. Air Force (ret.)
Penn Valley, California

Editors' reply: The article describes the F-104 as an aircraft designed to respond to the first-generation MiGs encountered in the Korean War. The MiG-21 was a second-generation MiG, and its primary adversary was the McDonnell F-4 Phantom II. The F-104 was not well suited to close aerial combat. However, neither the early MiGs nor the MiG-21 could have caught it when it came to straight-line flying; then, the F-104 would have indeed "left them in its contrails."

Scramjet Ancestors

Fresh out of the Massachusetts Institute of Technology in the early 1960s, I went to work on a program to develop a Mach 7 hydrogen-fuel supersonic combustion ramjet ("Outback Scramjet," Oct./Nov. 2002). We started with a Mach 3 supersonic combustion wind tunnel that ran on vitiated air, which was heated by combustion of hydrogen and oxygen upstream of the test section. Using a four-inch-by-four-inch tunnel, we achieved hydrogen detonation across both normal and oblique shock waves.

But we needed a cheap and simple way to demonstrate that our engine designs actually worked at Mach 7. My plan was to design an eight-inch-diameter annular test engine and propel it to Mach 7 at 70,000 feet on top of a sounding rocket. But the 1960s space program ate up the funding for air-breathing propulsion research.

Theodore C. Krave
Phoenix, Arizona

While working at Marquardt Co. in 1966, I was involved in demonstrating that we could boost a 10-foot dummy scramjet to Mach 5.5 at 50,000 feet. The dummy was fully instrumented and was mounted on top of a 20-foot Aerojet Junior solid-propellant motor. Once the booster burned out, an explosive device would separate the dummy vehicle, and two small rockets would accelerate it away, much as if the scramjet had ignited.

The flight took place at Vandenberg Test Range in California in February 1967. All parameters were met, and the data telemetered to mission control. Three future flights with actual scramjet engines were planned, but the Air Force contract was canceled.

Joe Tobin
West Hills, California

An Early Member of the Cub Club

I have an old Taylor Aircraft Co. promo card that advertises Cubs for as low as $1,270. That's far less than the $20,000 to $35,000 that vintage J-3s are going for today ("Yellow Fever," Soundings, Oct./Nov. 2002). I soloed in a J-2 on August 17, 1936. After building up a total of 10 hours, I graduated to the J-3. I'd still like to do a couple of touch-and-go's in a Cub, but I'm 82 with diminished eyesight, so that's not in the cards.

Paul A. Hunter
Newport News, Virginia

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LETTERS

Took a Licking and Kept on Ticking

The F-105 was also quite vulnerable to gunfire ("Shoot 'Em Up," Oct./Nov. 2002). The flight controls were controlled by two sets of hydraulic lines running close to each other, so a hit in that general area could cause the loss of the aircraft.

To minimize the vulnerability, engineers installed a cable system that allows the pilot to regain some control if the hydraulic lines were hit. Not much, just enough to maintain level flight and point the aircraft toward safe territory.

David Barlin
Marlboro, New Jersey

Wanted for Interplanetary Plantnapping

William E. Burrows' concept of an Alliance to Rescue Civilization ("Emergency Exit," Commentary, Oct./Nov. 2002) sounded familiar to me. In 1971, I worked on a science fiction film called *Silent Running*. The movie is about a plan to save all of Earth's botanical specimens aboard a huge space freighter, USS *Valley Forge*, until the planet was "cleaned up" and ready to replant. Eight years into the project the money runs out. The freighter's commander, Freeman Lowell (Bruce Dern), is instructed to blow up the specimens and return home. Unable to do the dastardly deed, he makes a run for it, trying to hide in Saturn's rings.

Rather than spoil the ending, I will leave it to those interested to rent the movie at their local video store.

Thomas F. Piskura
Sherman Oaks, California

It's Our Sun and Our Fun

In "Not Your Father's Learjet" (Soundings, Aug./Sept. 2002), Roger Mola refers to "the Experimental Aircraft Association's Sun 'n Fun Fly-In." Sun 'n Fun is an independent, non-profit organization; it has its own board of directors, leadership team, staff, and volunteers, and its legal name is actually "Sun 'n Fun Fly-In, Inc."

Our annual Fly-In, on the other hand, is called the "Sun 'n Fun EAA Fly-In." The "EAA" does not signify ownership or affiliation. Rather, it recognizes the support EAA leadership and members have provided to Sun 'n Fun over the past 20 years.

John Burton
President, Sun 'n Fun Fly-In, Inc.
Lakeland, Florida

COURTESY DOUG PARKER

Visitors leave flowers and flags at this B-52 crash site in Maine.

A B-52 in Ruins

"All That Remains" (Oct./Nov. 2002) brought back memories of the first crash site I ever visited. On January 24, 1963, a B-52 practicing low-level radar penetration encountered rough turbulence. It lost its vertical stabilizer and broke up, crashing about eight miles northeast of the Greenville/Moosehead Lake area in Maine. The pilot and navigator survived by ejecting. The pilot had a total parachute malfunction, but thanks to tree branches and deep snow, he survived. The other six crew members died.

At the site, you can see all kinds of remains of the huge aircraft (above): Yards of aluminum, wire, wheels and tires, landing gear struts, and the rearmost portion of the fuselage, where the tail gunner would have sat, are all easily accessible.

Doug Parker
Indianapolis, Indiana

Correction

Oct./Nov. 2002 "Sikorsky's Piano Man" (Oldies & Oddities): In the photograph, Igor Sikorsky is on the right, and Baron Nicholas Solovioff is on the left.

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—AEROSPACE ENGINEER ED SACHTLEBEN stands before the Hughes H-1 Racer in the Museum's Golden Age of Flight Gallery. Designed by Howard Hughes and Dick Palmer, Hughes smashed the world speed record and transcontinental speed record with the H-1 in the 1930s.

For years, billionaire Howard Hughes' aircraft company was on the cutting edge of aviation. With a new engineering degree, Ed Sachtleben knew Hughes Aircraft was where he wanted to be. That began a 34-year career of designing satellite control systems — and a lifetime of admiration for Mr. Hughes and his engineers.

Ed Sachtleben knows the National Air and Space Museum shares his respect for aviation and space history. He's proud to have included the Museum in his estate, and is now a member of the *Smithsonian Legacy Society*.

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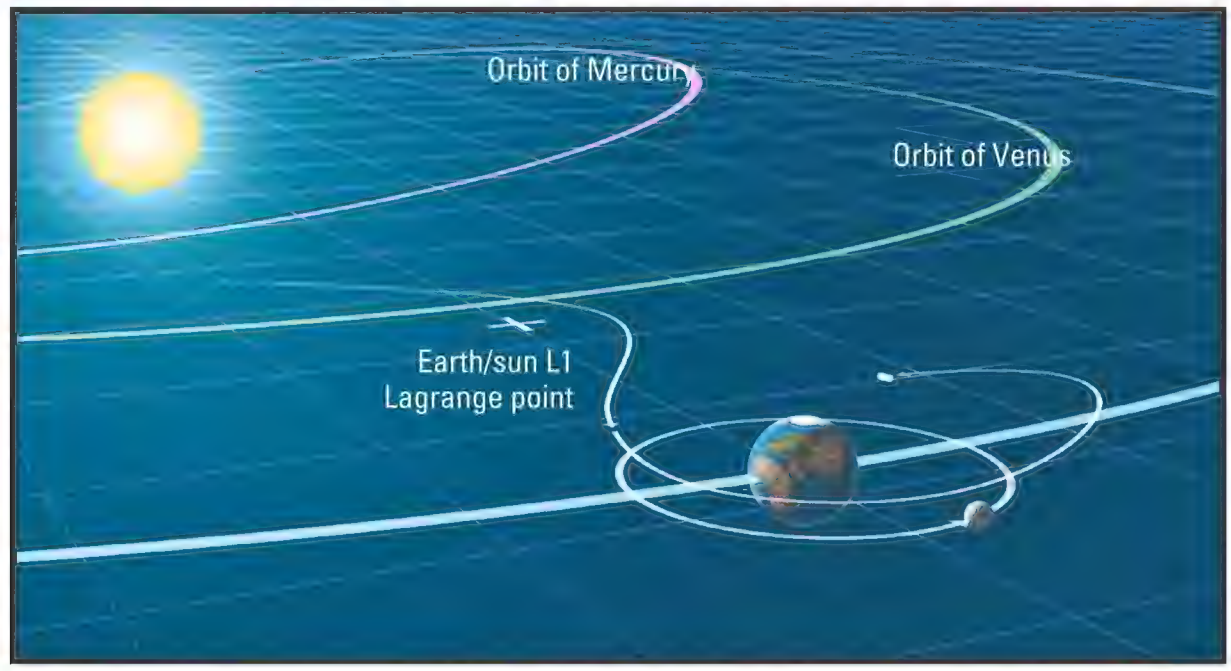
Earth to Saturn 4B: Gotcha!



JOHN MACNEILL

The Apollo 12 rocket stage that "escaped" the sun's gravity and is presently orbiting Earth is the first known case of an object being captured by Earth.

Fed up with Arizona's rains last summer, Bill Yeung headed for clearer skies in a camper bulging with telescopes. The observatory on wheels ended up in southern California, where, in an El Centro RV park, the amateur asteroid hunter set up a quartet of 18-inch telescopes.

What he found was not his 1,732nd space rock, but his proverbial 15 minutes of fame. "Spotting the 60-foot third-stage rocket of Apollo 12 is not an everyday event," says Yeung. The portion of the Saturn V that launched Charles Conrad, Richard Gordon, and Alan Bean to the moon in 1969 somehow was back in Earth orbit after a 31-year absence.

Thinking it was a near-Earth asteroid, Yeung notified the Minor Planet Center in Cambridge, Massachusetts. Soon skywatchers around the world were pointing their own telescopes at the mysterious satellite, designated J002E3.

"It's a great detective story," says Paul Chodas, a NASA astronomer who computed the orbit at the Jet Propulsion Laboratory in Pasadena, California, and deduced that J002E3 was a temporary visitor. His analysis showed it likely escaped Earth orbit in March 1971, would now orbit Earth six times, then return to orbit the sun next June. "It's not your usual boring elliptical orbit," says Chodas.

J002E3 is traversing an interplanetary superhighway whose interchanges are the points in space where one celestial body's gravity balances another's. These libration points serve as portals through which spacecraft can travel. Whatever Yeung spotted had slipped through the portal called L1, one million miles from Earth.

No active spacecraft were tracing such a chaotic path, and Chodas and other astronomers figured relics of several U.S. and Soviet robotic moon probes were too small to be considered. Beginning with Apollo 13 in 1970, spent Saturn IV-Bs—the third stages—were crashed on the lunar surface for seismic studies. That left the IV-Bs from Apollo 8, 10, 11, and 12. After executing the translunar injection burn that shot the Apollo spacecraft out of Earth orbit, Apollo 12's IV-B was supposed to follow its predecessors into heliocentric orbit. An excessively long engine firing left it circling Earth in a 43-day orbit—similar to that of J002E3. Eventually, the spent booster vanished.

On September 17, at the University of Arizona's Steward Observatory, Carl Hergenrother and Robert Whiteley looked at the object's reflected light with a 61-inch telescope and an array of filters. They saw paint. At the Massachusetts Institute of Technology in Cambridge, Richard Binzel and Andrew Rivkin were puzzling over data from NASA's Infrared Telescope Facility in Hawaii when they got e-mail from Hergenrother and Whiteley. "We combined our two data sets and produced a single spectrum spanning the visible and infrared," Rivkin says. Adds Hergenrother: The data "confirm that J002E3 is a dead ringer for white titanium oxide paint." The Saturn IV-B wore that very paint.

As the media interest subsided, Yeung resumed his hunt for asteroid no. 1732. Having learned he had bested one of the nation's foremost observatories, MIT's Lincoln Near Earth Asteroid Research Project, Yeung says, "It's a lot of fun to beat LINEAR by a couple of days."

—Beth Dickey

UPDATE

Aviation Fair Founders

For years the aviation community has buzzed about Aviation World's Fair 2003, set to run April 7 to 27 at Newport News-Williamsburg Airport in Virginia (see Moments & Milestones, Oct./Nov. 2002). The question on everyone's mind: *Will it fly?* As of late October, the answer was *Not a chance*—at least not in Virginia.

On October 2, state officials cut any further investment. After a week of intense lobbying, organizer Tom Kallman canceled the fair, saying he did so "with indescribable disappointment."

The fair was to include aerobatic displays and flybys, static exhibits, historical replicas, and national and commercial pavilions. Kallman predicted one million visitors and a $207 million boon to the local economy. He had lined up 110 of his goal of 1,600 exhibitors, and NASA had committed to sponsor 15,000 square feet. A roster of airshow performers had been mailed deposits.

"Event planners had been unable to reach minimum goals for advance ticket sales, unable to sign any major sponsors, and unable to generate significant exhibitor revenues," said Virginia Transportation Secretary Whitt Clement in a press release.

Kallman says his own firm stood to lose $4 million, and says his company may sue the Commonwealth of Virginia for breach of contract. "If there is a way, this show will go on," he adds.

—Roger A. Mola

Stick Buddies

At the Vietnam Helicopter Pilots Association convention in Las Vegas last July, UH-1 Huey pilots Jack Breedlove and John "Jack" Heslin met for the second time in 35 years. Their last meeting had been on the Ho Chi Minh Trail, when Breedlove's Army helicopter swooped in to pick up Heslin from his downed helicopter, which had been shot up over Laos. "My wife wanted to thank him for rescuing me," said Heslin, "but he said, 'I was just doing my job.' "

VHPA added 800 new members in the first six months of this year. VHPA-ers—more than 11,000 in 14 chapters and including a number of Vietnamese pilots—will tell you the new members signed up because volunteers spent thousands of hours recruiting, and because of a mass mailing sent to 8,000 former "stick buddies." But the movie *We Were Soldiers* helped. The movie, based on the Harold G. Moore and Joseph Galloway book *We Were Soldiers Once, and Young*, about the Air Cavalry in Vietnam, was notably realistic. "There were only three or four inaccuracies, such as in reality the pilot in the war zone sits in the left seat to see well," says former Huey pilot and 1995-'96 VHPA national president Ken Fritz. "You can't see over the control panel in the right seat."

VHPA historian and two-tour veteran Mike Sloniker says support also comes from a surprising source: women relatives. "I get contacted by daughters and daughter-in-laws who say Dad can't remember anything, so they—these 25-year-old mothers—want to be able to tell [their children] 'This is what Granddad did in the war.' It's the daughters who keep the heritage alive."

The 108-degree Las Vegas heat reminded association members of their Vietnam service. Of the 1,266 in attendance, 296 were first-timers. Nearly 2,200 helicopter pilots died in Vietnam (plus 2,500 crew members). They were indeed young, 25 years old on average. Eighty-six percent were warrant officers; the remainder were RLOs—real live officers.

The VHPA, growing by dozens a day, is well into planning for its 2003 convention. Annual Directory Editor and former Air Cavalry pilot Mike Law says, "This year's edition will be 30 to 40 percent larger than last year's." Quite an accomplishment for an organization that began with 13 guys at a barbecue. But perhaps the recruiters are fighting a new battle, this one with time. Many of the veterans of the Vietnam War are now in their 60s and 70s. Since the end of the war 25 years ago, 2,000 more helicopter pilots have died. And there's much more work to be done; the VHPA has 14,000 names with no addresses. (Visit *www.vhpa.org*; email *HQ@vhpa.org*; or call 800-505-VHPA.)

—Bob McCafferty

WORK IN PROGRESS

Ford Tri-motor

Greg Herrick, the driving force behind the 2003 National Air Tour, which will re-create the Ford Air Tours of the late 1920s (see "On the Road Again," Soundings, Aug./Sept. 2002), plans to have Ford Tri-motor serial number 10, registration number NC-1077, restored in time for the September kickoff. The oldest Tri-motor in existence, it was built in 1927, and that year flew Evangeline Lindbergh from Detroit to Mexico City to meet her son Charles for Christmas. (He was touring Mexico in the *Spirit of St. Louis*.) It was also the airplane in which the pilot took his future bride, Anne Morrow, and her sisters for their first airplane ride.

Number 10 spent the rest of its career as a transport, sometimes hauling sightseers over Niagara Falls, sometimes hauling fish around Canada. It ended up in pieces in Alaska, and in 1956 the fuselage and tail were trucked south to the United States. Today it's being rebuilt by Maurice Hovius and his restoration crew at Hove-Aire Inc. in Vicksburg, Michigan.

"We have the entire structure, less engines and instruments," Herrick says. "The actual construction prints from the Ford archives are being used to ensure number 10 is exactly as it was."

NATIONAL AIR TOUR

Undergoing restoration in Michigan, this Ford Tri-motor ended its career as a mail hauler in Alaska's Yukon.

FIRST FLIGHT

Mission Accomplished

After 10 years of work and an infusion of $2.5 million, the Lockheed P-38 extracted from the ice of Greenland in 1992 flew for the first time in 60 years last October in Middlesboro, Kentucky. Reno air race pilot Steve Hinton made a 30-minute flight that included low passes for the audience of 25,000. A History Channel crew filmed the event for its March 3, 2003 documentary on the saga of *Glacier Girl*, the name it was given after it was de-iced. The airplane was one of six P-38s on a 1942 ferry flight that, along with two B-17s, encountered bad weather, ran low on fuel, and found their intended Greenland landing site closed, forcing emergency landings on the ice cap. Over the years, glacial shifting had moved all eight aircraft two miles from their touchdown site and buried them under 268 feet of ice. *Glacier Girl* will appear at airshows, then serve as centerpiece of the Lost Squadron P-38 Museum in Middlesboro.

CHARLES STITES

An Astronaut's Arboreal Legacy

It's been 30 years since humans last set foot on the moon, but thanks to Apollo 14 astronaut Stuart Roosa, across the nation and around the world, there stand scores of living reminders of that feat. In Philadelphia's Washington Square Park, there's a 40-foot sycamore; in Mission Plaza in San Luis Obispo, California, a 60-foot redwood; on the lawn of the Sebastian County Courthouse in Fort Smith, Arkansas, a 50-foot loblolly pine. Commemorative plaques identify them as "moon trees."

Though never alive on the barren lunar landscape, all grew from seeds that orbited the moon 34 times in 1971 inside Roosa's "personal preference" kit. "When you're selected to fly, you're given a small personal [container] to take things into space," says Air Force Lieutenant Colonel Jack Roosa, explaining that his father, who died in 1994, decided against the usual fare—coins, stamps, mission patches. "As Dad was searching for ideas, he started reflecting on his life. He was a smoke jumper with the Forest Service and always had a strong pull to the outdoors."

Stan Krugman, now retired as director of forest management research for the U.S. Forest Service, supplied the seeds—some 50 of each of six species: redwood, Douglas fir, sycamore, loblolly pine, slash pine, and sweetgum. Upon Roosa's return, Forest Service employees planted the seeds that had been in lunar orbit, as well as control seeds, beginning an intended 60-year monitoring project.

But as the moon trees appeared to grow quite normally, questions about possible effects of weightlessness or cosmic radiation were forgotten, and the seedlings became public relations tokens. The emperor of Japan received a seedling. One went to the capital of Brazil. Senators and Congressmen received them for their home states. All told, hundreds of moon trees were planted, including a sycamore at a Girl Scout camp in Cannelton, Indiana. Dave Williams, a scientist at NASA's National Space Science Data Center, has tracked down nearly 40 moon trees and has photos of some at his Web site (*http://nssdc.gsfc.nasa.gov/planetary/planetary_home.html*).

It's hard to imagine the White House was overlooked—and Krugman's files indicate a loblolly pine was planted there in 1976—but a White House spokesman insists there's no moon tree on the grounds and none was planted.

"In retrospect, I think it was one of the most brilliant things my father could have packed," says Jack Roosa. "Something alive, that can exist on its own and provide—for decades already, and maybe centuries—a reminder of the Apollo mission."

—John Grossmann

RICHARD THOMPSON

BEST IN SHOW

Fairey Tale

At last September's National Championship Air Races in Reno, Nevada, a Fairey Firefly captured both the National Aviation Hall of Fame People's Choice Award and the Rolls-Royce Aviation Heritage trophies. The World War II British Royal Navy aircraft was initially used for reconnaissance and later served as a fighter and anti-submarine patroller. Some 1,700 Fireflies were built; a mere handful remain airworthy today. The Firefly's owner, Eddie Kurdziel of Del Mar, California, has configured the airplane to represent a Firefly as it was operated by Royal Navy 817 Squadron aboard the HMS *Sydney* during the Korean War.

CAROLINE SHEEN

Left to right: Former astronaut Gene Cernan, Don Lopez of the National Air and Space Museum, a video team technician, winner Eddie Kurdziel, and Rolls-Royce president James Guyette.

Reprise: Teachers in Space

When NASA selects its next class of astronauts, the search committee will be looking for experiences other than the conventional preparation: years in a fighter cockpit or a prestigious university post. Among the candidates who score the most points will be those who've spent their career in elementary and high school classrooms.

NASA plans to include at least one educator in all future astronaut class selections. "We will recruit teachers to educate students from the unique vantage point of space," says NASA administrator Sean O'Keefe.

The first post-*Challenger* educator-turned-mission specialist will be former teacher-in-space candidate Barbara Morgan, 50, who trained as a backup to *Challenger* astronaut Christa McAuliffe in 1985-'86. Twelve years later, O'Keefe's predecessor, Dan Goldin, plucked Morgan from her Idaho elementary school classroom to train as a full-time astronaut. Earlier this year O'Keefe awarded Morgan a spaceflight pegged for 2004, after the current phase of space station construction ends.

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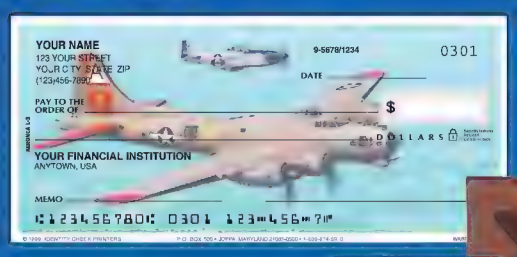

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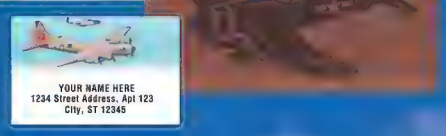

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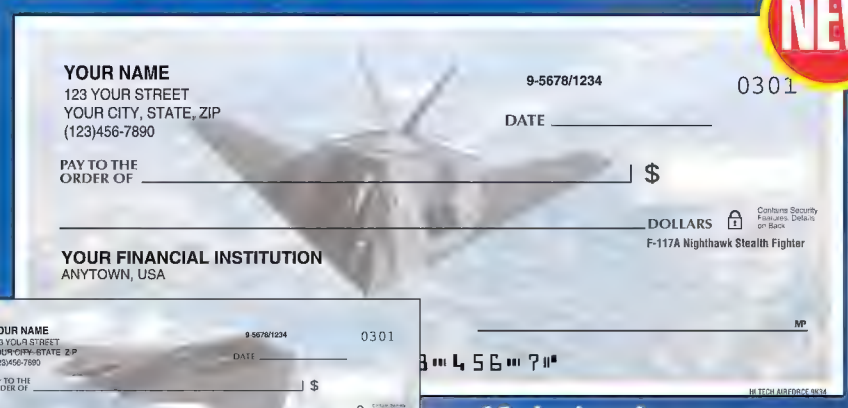

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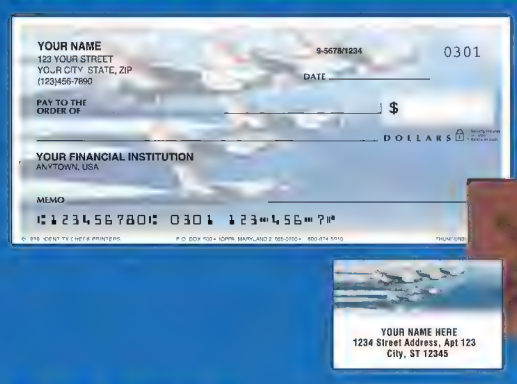

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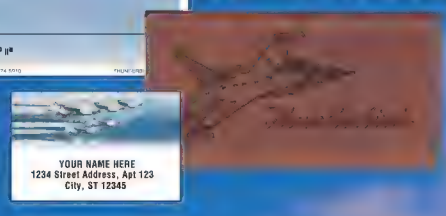

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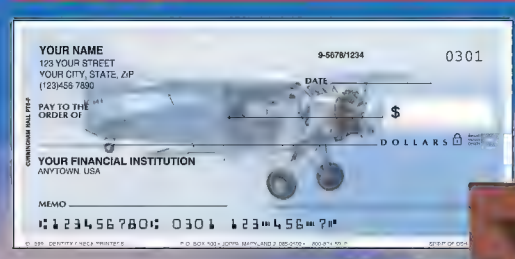

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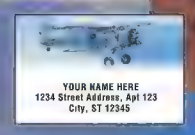

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Although the risks of flying aboard the shuttle are significantly less than when McAuliffe and her six companions made their ill-fated 1986 flight, the odds of a fatal accident are still about 1 in 500.

Morgan, married with two teenage sons, takes those statistics in stride. "When you decide to do something like this, you look at the pros, you look at the cons, you decide if what you're doing is important, and if it's important, it's worth doing," she says. "Then you do exactly what the astronauts do: Go forward with a happy heart and don't dwell on the risk."

—Irene Brown

A Walk in the Woods

In the primeval overgrowth, you can't even see the aircraft until you're within 15 feet of it. Shredded fabric hangs from the tail and ailerons like the moss on the surrounding trees. Every so often the wreck shudders and groans on its precarious hillside perch.

The Royal Canadian Air Forces Canso made its last takeoff on February 10, 1945. The Canadian Vickers-built PBY-5A belonged to a squadron of Canso patrol bombers based on the rugged west coast of Vancouver Island, British Columbia (see "Restoration: Going the Distance," p. 38). After the bombing of Pearl Harbor in 1941, a Japanese invasion of North America became a tangible threat, and the United States and Canada responded with a buildup of military defenses along the Pacific Coast.

Like a duck out of water, a Canso that crashed in 1945 perches precariously on a Vancouver Island hillside.

DARRELL OHS

The Canso took off from the Tofino runway for Coal Harbor, a station on the north end of Vancouver Island. Shortly after takeoff, the port engine quit. Flying Officer R.J. Scholes turned back to the airfield, but the aircraft was skimming the treetops as he pulled the nose up into a full stall and crashed at the bottom of a heavily wooded hillside.

The aircraft stood almost upright on its nose before settling back down, and the starboard engine, under full power, tore off and caught fire. The left wing fuel tank ruptured, spouting gasoline.

Crew member Lace Knechtel saw that the port engine was also on fire. He thought that everyone else was dead until he heard someone swearing. After an engineer passed him a fire extinguisher, Knechtel climbed out over the wing and put the fires out. Another Canso from the squadron directed a search party on foot to the aircraft and crew members, all of whom had survived.

Fifty-five years later, I hiked through the rainforest and across the bogs to find the Canso. There is no official trail to the site, and that probably gives it more protection from raiders and pillagers than its registry as an archeological site with the Heritage Conservation Act of Canada. Still, over the decades small parts have been carried off, and graffiti—names, initials, dates—covers the fuselage.

—Darrell Ohs

COLLECTIONS

AF ARMAMENT MUSEUM

Air Force Armament Museum

100 Museum Drive
Eglin Air Force Base
Florida, 32542
(850) 882-4062
Open daily, 9:30 a.m. to 4:30 p.m. Closed Federal holidays.

The first thing you notice as you drive up to the Armament Museum on Eglin's east side is a B-25 Mitchell in the livery of Doolittle's Raiders. The tail number is 02344, that of the airplane flown by Jimmy Doolittle himself from the carrier USS. *Hornet*. It's not the real thing, however. "All those airplanes were destroyed," says museum director Russ Sneddon.

But most of the museum's 28 aircraft are real warriors: the B-57 in night livery, the B-52 in Vietnam colors, the B-17 as it flew over Europe in 1943. Around back there's a collection of fighter-bombers from Korea, and on the building's west side it's all modern: F-15, F-16, A-10. Exotics such as an SR-71, F-111, F-104, F-101B, and MiG-21 augment the zoo outside.

Inside, suspended from the ceiling over a P-51D, a P-47D, and an F-105, is a Republic/Ford Aerospace JB-2 Loon, a copy of the V-1 pilotless flying bomb launched by Nazi Germany. "[Eglin] got a number of [V-1s] after the war," says Sneddon. "They created a test facility and launched them into the Gulf of Mexico to make evaluations." Some 1,000 JB-2s were built; a number of them were sent by aircraft carrier to the Pacific Ocean for a possible invasion of Japan, but they were never used in combat.

—Phil Scott

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Cold War to Scale

My fascination with Soviet and Russian aviation dates to the late 1960s, during the iciest days of the cold war, when the Soviet Union's military machine was perceived as a formidable force. Its newest fighters and bombers, flown at airshows over Moscow's Tushino and Domodedovo fields, intimidated the West. Those demonstrations eventually inspired me to assemble a collection of 55 models of Soviet and Russian aircraft that were built from the late 1940s to the 1990s: bombers, transports, fighters, helicopters, and experimental types little known outside the Eastern bloc. In 2000, I donated my collection to the National Air and Space Museum.

From 1960s Soviet airshows, Western magazines such as *Aviation Week & Space Technology* would run grainy photographs of the then-new MiG-23, MiG-25, and the huge and exotic delta-wing M-50 "Bounder" strategic bomber, among others. Taken from great distances with long telephoto lenses, the pictures were more tantalizing than revealing, and as I pored over them, I would imagine what it would be like to see this heavy metal with my own eyes. At the time, and for many years afterward, such an opportunity seemed highly unlikely.

But several years after the cold war ended, I joined a group of aviation fans in Great Britain and flew to Moscow. We visited the fabulous Russian military aviation museums at Monino, outside Moscow, and Khodynka, near the capital's center. Together they house examples of nearly every major Soviet/Russian military aircraft produced since the 1930s. We also enjoyed private tours of the once-top-secret Zhukovsky Flight Test Center, Russia's equivalent of Edwards Air Force Base, and Kubinka air force base, both near Moscow.

After returning from the trip, my first of six to Russia, I started my Soviet/Russian aircraft collection. I knew this would be a challenge because few such models were available in the United States. Fortunately, I saw an advertisement in an aviation magazine that connected me to Alex Panchenko, a Ukrainian who had immigrated to California in 1989, following service in the Soviet army. "When I arrived in the U.S., all I had with me was $20 in cash, a pair of jeans, two T-shirts, a couple of books, and some Soviet aviation pins," recalls Panchenko. Friends suggested that he try to sell his pins at an airline collectibles convention. Panchenko supplemented the pins with aircraft models and posters sent to him by his parents, who were engineers at the Antonov design bureau in Kiev, which had developed some of the largest transport aircraft ever built.

At the convention, Panchenko quickly sold everything he had. "I made more money in two hours than I had for the whole year, working two jobs," he says. He realized that if he could obtain a steady supply of salable material, he had the makings of a unique business.

At the Movies

On September 18, the National Air and Space Museum premiered *Straight Up! Helicopters in Action* at its Lockheed Martin IMAX Theater. Filmed over a period of 18 months on locations in Africa, Europe, and North America, the 42-minute film shows viewers the diverse ways that helicopters are employed around the world. The film includes sequences of a U.S. Marine Corps reconnaissance mission, a U.S. Coast Guard air-sea rescue, relocation of endangered black rhinos in South Africa, a United Nations delivery of humanitarian aid in war-torn Sierra Leone, a U.S. Customs drug interdiction off the coast of southern Florida, an aerial repair of 500,000-volt power lines, and an alpine rescue and medevac following an avalanche. Narrated by actor Martin Sheen, *Straight Up!* features more than 30 rotorcraft, from the Pitcairn autogiro to the Boeing-Sikorsky RAH-66 Comanche. *Straight Up!* will also be shown at the Steven F. Udvar-Hazy Center, which will open next year at Washington Dulles International Airport in northern Virginia. The Hazy Center will house an extensive vertical-flight collection.

Left to right: The Tupolev Tu-114 airliner could transport up to 170 passengers. The Sukhoi S-37 is a technology demonstrator for a proposed Russian fighter. The Tupolev Tu-91 was canceled in the mid-1950s after Soviet premier Nikita Khrushchev ridiculed the homely attack aircraft. This Sukhoi Su-27 fighter carries the markings of the Russian Knights, a demonstration team.

SK FILMS, INC

Inspired by the autogiro, the GBA Hawk 4 gyroplane, which appears in Straight Up!, *is a recent rotorcraft design, with a wing that provides lift at high speeds.*

With the help of his parents and their Antonov connection, friends in Russia and Ukraine, and trips back to both countries, Panchenko built a considerable inventory of aviation memorabilia, including desktop models made by craftsmen in the Antonov model shop.

ERIC LONG (4)

The models are hand-made of resin, fiberglass, and wood, with metal details and accurate renditions of landing gear. Some of the replicas were made decades ago in design bureau model shops, but most were made by a small network of craftsmen in Russia and Ukraine, many who had once worked in the aircraft-model shops of Sukhoi, Mikoyan, and Gurevich. In the post-Soviet era, military spending was sharply reduced and these bureaus were drastically downsized; many of the workers were out of jobs and available to make the models as orders came in from Panchenko's customers.

My collection includes seaplanes and amphibians made by the Beriev design bureau, one of the few companies in the world still producing such aircraft. Other collection highlights are models of seven generations of MiG fighters, from the MiG-15 to the MiG-31, along with several prototypes that did not see production. I also managed to obtain several Tupolev and Ilyushin jet airliners in Aeroflot markings and the Yakovlev design bureau's three pioneering vertical/short-takeoff-and-landing aircraft.

The models will be displayed at the Steven F. Udvar-Hazy Center, scheduled to open in December 2003 at Washington-Dulles International Airport in Virginia. "These models fill a cold war void," says Museum specialist Tom Dietz, who oversees the Museum's model aircraft collection. "During that time there were very few opportunities for the Museum to collect such models. In the absence of the full-sized aircraft, these models are the only surviving three-dimensional representations we have."

—Gene Eisman

MUSEUM CALENDAR

December 28 Monthly Star Lecture: "Wondrous Winter Nights." Join George Mason University astronomer Harold Geller on a tour of winter's night skies. Albert Einstein Planetarium, 6 p.m.

Curator's Choice
Once a week a National Air and Space Museum curator gives a 15-minute talk about an artifact or subject of interest. Meet at the Museum Seal near the Information Desk at noon. Dec. 4, " 'Flopnik': The Vanguard TV-3 Disaster"; Dec. 11, "Gene Cernan's Apollo 17 Suit"; Dec. 18, "Robert Goddard's May 1926 Rocket."

Hours The National Air and Space Museum is open from 10 a.m. to 5:30 p.m. every day except December 25. General admission is free.

Location The National Air and Space Museum is located on the National Mall at 7th Street and Independence Avenue SW, Washington, DC 20560. The nearest Metrorail stations are L'Enfant Plaza and Smithsonian.

Food The Wright Place serves breakfast and lunch fare from McDonald's, Boston Market, and Donatos Pizzeria. Hours: 7:30 a.m. to 5 p.m., Monday through Friday, and weekends from 9 a.m. to 5 p.m.

Lockheed Martin IMAX Theater
View Earth from the open cargo bay of the space shuttle at the National Air and Space Museum's Lockheed Martin IMAX Theater, which has a screen seven stories wide and five stories high and a digital surround sound system. For more information, call (202) 357-1886.

Paul E. Garber Preservation, Restoration and Storage Facility
It's closing on March 31, 2003, so now is the time to get a behind-the-scenes look at the National Air and Space Museum's aircraft restoration workshop in Suitland, Maryland. For more information, call (202) 357-1400.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.edu *or call the Smithsonian Information line at (202) 357-2700; TTY (202) 357-1729.*

Yawning Across the Atlantic

It's always the same at the end of a long deployment. One group of pilots did one last shopping trip in "The Land of the Big BX (Base Exchange)," while the other group went out for a last meal at their favorite Stateside restaurant. In less than 12 hours, all of us would re-create one of the greatest feats in aviation history, though with no fanfare. We were about to take eight McDonnell Douglas F-15C Eagles across the Atlantic Ocean, from Tyndall Air Force Base in Florida to our home base, Spangdahlem Air Base in Germany: a 4,000-mile routine flight.

Earlier today, we'd had our pre-brief from Second Air Delivery Group, a group of pilots and navigators whose sole job was the safe deployment and redeployment of fighter squadrons on temporary duty assignments. This time we were returning from three weeks at Nellis Air Force Base near Las Vegas, followed by another two weeks at Tyndall.

As the groups straggled back from downtown, some of the pilots reviewed the mountains of maps and publications, covering every possible contingency, that Second Air had issued us. Others just rested, savoring their last opportunity to channel surf Stateside TV. Some of us gathered in each other's rooms, debating Second Air's philosophy that it was safer to take off at 2:00 a.m. tomorrow and land in Germany before sunset than to leave at a more civilized hour and have to land at night. To follow that schedule, we'd have to go to sleep at 4:00 p.m.—just a few hours away. A few pilots joked that some whiskey would help them sleep.

No matter how prepared we think we are, sitting in a briefing room at midnight, waiting to begin our day, always shocks the system. As we filed in, we noticed that our Second Air representative didn't look pleased. The weather around Keflavik, Iceland, one of the primary divert bases we could use if one of us couldn't air-refuel from our tanker over the Atlantic, was below minimums. Without an alternative for each air refueling, the mission would have to be scrubbed.

So there we were with a full night's sleep at 2:00 a.m. and no place to go. Later that morning, more than one of us was sipping a Bloody Mary, watching the sun come up over the Gulf of Mexico.

The next night was very much the same, but the sleeping seemed easier after a night of adjusting. As the last few pilots straggled in, we got our final briefing. The weather looked like a go. There was some cloudiness around our first two refuelings (we had five scheduled), but all the divert bases looked good, and there were no showstoppers along the route.

About half of us had done this before. Some of us wondered if that experience was actually a benefit. One's first Atlantic crossing always had an air of excitement, but the old hands already knew what they were in for: droning hour after hour, trying to find a comfortable way to sit in the single-seat cockpit. There was always a chance something would go wrong far from land. The biggest threat, however, was the sheer boredom.

Some of the pilots had made simple games that we could play over the radio to keep everybody alert. One pilot had a Battleship game grid printed on a sheet of paper. Another was sorting through Trivial Pursuit cards, making sure the ones he chose wouldn't create long intervals of ignorant silence. Nobody wanted to feel miserable *and* look stupid.

The flight brief was short. We were taking eight aircraft in two cells of four, separated by 30 minutes. Each cell would fly on the wing of a KC-10 that we would join over Georgia. The KC-10 would "drag" us to the southern coast of England, and from there we would press on into Germany on our own. As long as we did everything the same way we trained every day, we would be sipping ice cold beers at the squadron bar before we knew it.

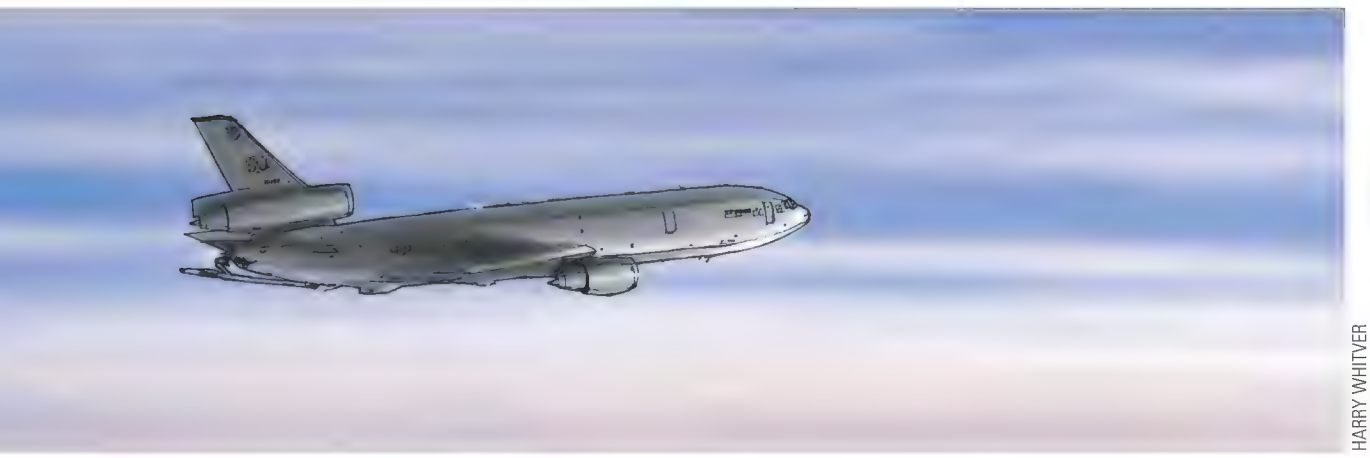
With those sudsy dreams, we stepped over to Life Support, where we hermetically sealed ourselves against the elements. For extended flights over cold water, we were required to wear anti-exposure suits to increase our survivability in the unlikely event we had to eject into the ocean and wait for a rescue. As we waddled out to our jets, one pilot quipped that they had forgotten to

include this scene in *Top Gun*.

As we got closer to the ramp, we could see the crew chiefs for each of our jets preparing for our arrival under the halogen glow of the stadium ramp lights. It took at least two crew chiefs per aircraft to launch us, and there was a smattering of every flavor of aircraft specialist milling around just in case one of us had a last-minute maintenance problem after we started engines.

The first cell began rolling down the runway, and we breathed a sigh of relief as each jet climbed into the darkness. Short-lived relief: One of the pilots was having a problem raising his landing gear. While this is much easier to solve than a problem lowering the landing gear, it would still prevent him from making the trip. He began to work his way over the Gulf of Mexico to dump gas and get down to a safe landing weight.

As we taxied to the end of the runway for our last-chance checks, we heard him and his chase aircraft lining up on a 10-mile final to land. Everything was going smoothly until on short final, the tower spotted a deer wandering onto the main runway. Not wanting to risk a collision with a multi-million-dollar aircraft, the tower quickly cleared the jet



HARRY WHITVER

to sidestep to the shorter parallel runway.

The shorter runway and the heavier-than-normal landing weight proved a dangerous combination. A shower of sparks was the first indication that the pilot didn't think he was going to be able to get the jet stopped by the end of the runway and had dropped his arresting hook. As advertised, the hook caught one of the cables strung across the departure end of the runway for just such occasions, and the jet slowed to a stop. With that crisis averted, one by one, our cell began our takeoff rolls.

Joining with a tanker at night is like flying into a black tunnel with only a dim light at the end. One by one, each of the four jets in our cell cycled down to the KC-10's refueling boom to check our air refueling systems and make sure that we would be able to take fuel. Air refueling from a KC-10 is simple. Once established in the proper position, roughly 15 feet down and 10 feet aft from the KC-10's belly, the boom operator in the back of the KC-10 "flies" the boom into the air refueling receptacle on your left wing. All you have to do is continue to fly formation with the tanker, assisted by an array of multi-colored lights constantly relaying your position in relation to the boom envelope. If you drift too far back, a yellow light on the belly of the tanker tells you to move forward. If you don't correct the problem and continue to drift aft, the light changes to red, and eventually will start flashing just before the boom disconnects from your aircraft.

If it looks like we're not following the instructions the lights are giving us, the boom operator may prompt us with an "Up five," meaning he wants us to move up five feet closer to the tanker. These prompts are quite costly in the fighter community. Each time the boom operator has to prompt you to correct your position, you owe a round of drinks to all the pilots in your cell.

All four of us made it on and off the boom and were able to take a brief shot of fuel to check our systems. We settled out to a comfortable position, about 50 to 100 feet off each of the tanker's wings.

As we reached our next air refueling point, or AR, the weather had started to worsen. We were now having to fly as close as five feet to the wing of the tanker to keep it in sight.

For this refueling, we are taking more than just the 1,000 pounds we took to test the system. We are filling to our more-than-27,000-pound fuel capacity. Each of us sits on the boom for 10 minutes while gas is pumped into our tanks at 3,000 pounds per minute.

This time, refueling takes a little bit more finesse. Not only do we have to deal with the lack of a horizon to indicate which way is up, our center of gravity keeps changing as fuel streams into our tanks, so we have to constantly trim the aircraft.

We are still in bad weather at our next refueling, but the sun has started to come up, increasing visibility a little. The refueling goes smoothly, and as the last fighter returns to its position on the wing of the tanker, the weather starts to clear and we can see the coast of Newfoundland slip beneath us as we head out into the Atlantic.

With the daylight and the improvement in the weather, we can fan out to as much as a mile from the tanker and enjoy a respite from the rigors of staying in position. Now we start breaking open the meals we were given at Tyndall and see what goodies we have.

The F-15 is an excellent aircraft for long flights. It has a roomy cockpit that allows you to spread out and make yourself at home. Pilots have figured out that one side of the cockpit, near the warning lights and heater, is good for warming up food, while the other side, with a deep map case, keeps things cool.

It's now about five hours into our flight, and we haven't seen land for the last two. No matter how many times you've crossed the Atlantic, it's usually about this point where you start noticing every odd sound the jet makes. Routine hydraulic switch-overs that you'd never noticed before now sound like the jet is coming apart. It's times like these that make us glad that McDonnell Douglas saw fit to put two engines on the F-15.

Another two hours and we're on our last AR. Our inertial navigation systems show us to be less than an hour from Germany as we start picking up glimpses of the northern coast of Scotland.

After a quick check of everyone's fuel, it looks like the winds will allow us to push ahead of the tanker and make the rest of the trip on our own. Thanking the tanker boys, we contact Scottish military air traffic control, climb up to 41,000 feet, and accelerate closer to Mach 1.

After the Atlantic, the English Channel seems like a swimming pool, and before we know it, we're past the Netherlands and being switched to Rhine Radar Control. It's unusually clear for this time of year in Germany, and we can easily pick out the field as we begin our descent into Spangdahlem.

Nine hours and 15 minutes after takeoff, the squeak of my tires on the runway welcomes me back to Earth. Seconds later, the control tower does the same: "Welcome back to Spang, sir. Right turn at the end, taxi to park."

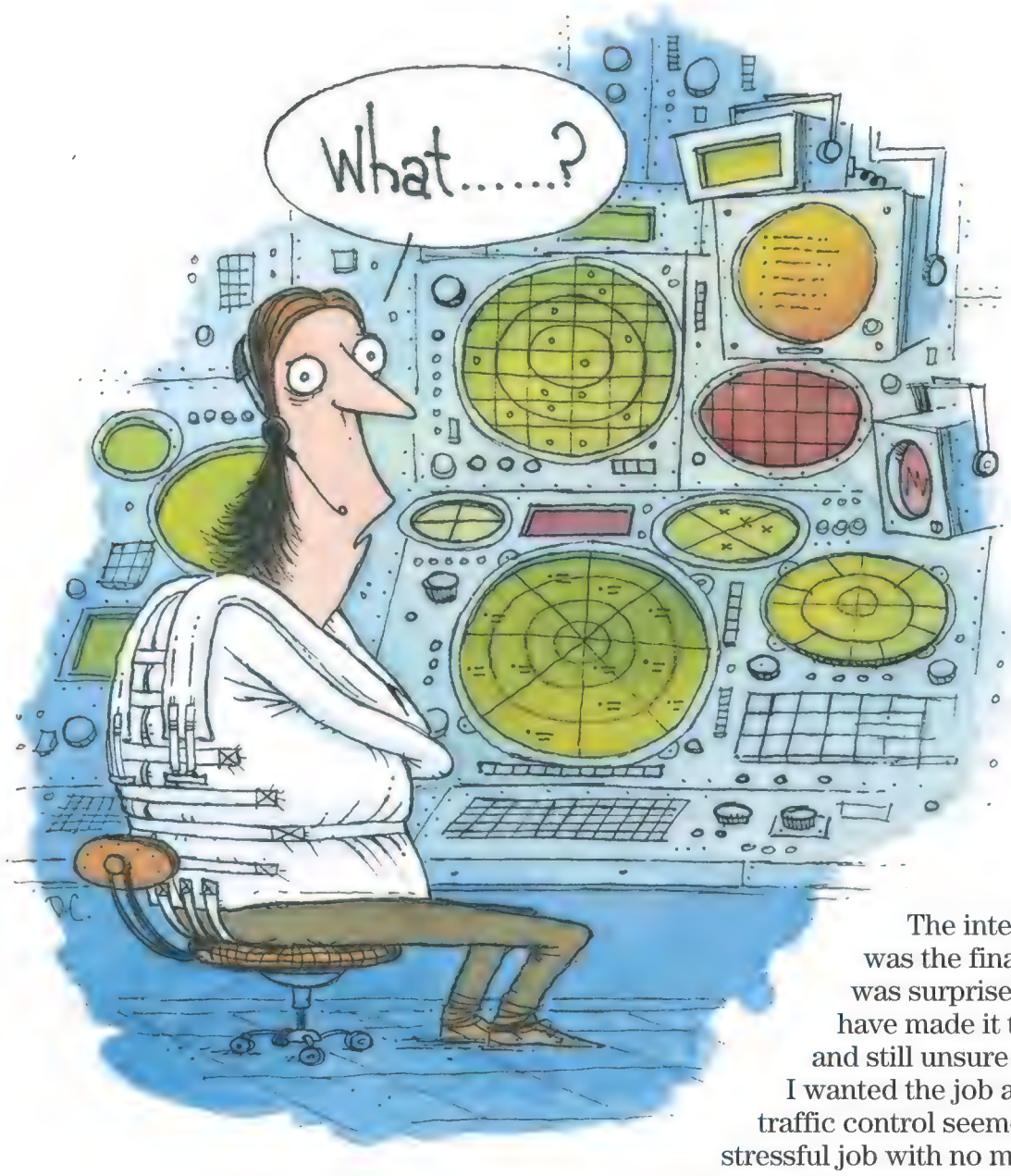
As I shut down the engines, my crew chief secures a ladder to the side of the jet and climbs up to take my helmet. "How was the flight, sir?"

Seventy-five years ago, there would have been thousands of people heralding my arrival as a triumph of technology. Today, there's only my wife and a fellow pilot with a cold beer, but I'm as happy as if I were Lindbergh himself.

"Piece of cake," I say as I unstrap.

—Russell Gregory

Profiled



DAVID CLARK

The civil servant at the employment office handed me the application I'd asked for. "Commissary clerk trainee, GS-3. You want to apply for air traffic controller too? We've got some openings."

"Sure," I answered. "And I'll take an astronaut application, if you've got one."

It was late 1981, and Ronald Reagan had recently fired thousands of striking controllers. I was fresh out of the Air Force, newly married, and had just moved to Fort Meade, Maryland, with my husband, who still had a year to go on his enlistment. I needed a job, so I filled out both applications. Two weeks later I was happily organizing shelves and memorizing prices at the commissary. Every few months, though, I would get a call from the Federal Aviation Administration to take another test.

My Air Force experience was useless for air traffic control. I had signed up to be a linguist, hoping the Air Force would send me to language school to learn Russian. Maybe I would become a diplomatic translator. Or a spy!

The Air Force had taken my request to learn Russian and assigned me to learn Polish instead. Most of my military career involved listening to Polish air force pilots doing touch-and-gos in MiG-15s, so I learned heaps of aviation jargon at the job, but it was all in Polish—surprisingly unhelpful for a future career with the FAA.

The FAA exam was a series of questions about airplanes on collision courses. They wanted to know if and where the airplanes would collide. After passing that test, I went back for a psychological exam of an extremely transparent nature. "Does the top of your head feel soft?" "Does it sometimes seem as if everyone is watching you?"

Years later, after I had observed controllers for a while, I realized that the psychological test had not been to weed out psychos, but rather to select a particular kind of psycho. Many controllers have an overinflated sense of order, becoming edgy if something is the tiniest bit out of place. You can see how this would be a good quality in a controller but not necessarily in the average Joe. In fact, I later knew a controller who was convinced that everyone really was watching him. His paranoia extended to threatening visitors who brought cameras to the control tower. His colleagues did their best to get along with his little quirks because he could flush out a backlog of departures faster than anyone.

After the psychological test came the physical exam. As it happened, the FAA was so shorthanded that the doctors and nurses conducting the tests did their best to make sure we passed. Didn't pass the eye test? Try again. The hearing test? Do it over, and this time pay special attention to that third set of tones.

Things went smoothly enough, though several of us waiting for our results became suspicious when the nurse kept finding small glitches in the electrocardiogram of a particularly handsome candidate. He had to go back for several bare-chested EKGs until the nurse was satisfied. With the results, I mean.

The interview was the final step. I was surprised to have made it this far and still unsure whether I wanted the job at all. Air traffic control seemed like a stressful job with no margin for error, and from what little I had seen of it on TV and in movies, the job was held by middle-aged men with crew cuts and short-sleeved white shirts.

My interview took place at the Washington Air Route Traffic Control Center in Leesburg, Virginia. I had some time to kill before the interview, and a friendly controller escorted me into the radar room. There were a hundred men and women at dozens of radar scopes. The room was neat and orderly. No one seemed stressed.

Later, in a tidy office, two men with crew cuts and short-sleeved white shirts asked me questions about my employment record and education. My experiences with Polish and with checking groceries did not seem to impress them. The interview at an end, I got up, replaced my chair exactly as it had been, equidistant from the ends of the table. I arranged the pencils on the table in order of size, perpendicular to the edge of the table, shook hands with the crew cuts, and left.

Two weeks later, I was an FAA employee.

—Helen Cota

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The Memory Foam Ultra mattress topper is cut into a grid pattern with six different zones for variable support, and a better night's sleep.

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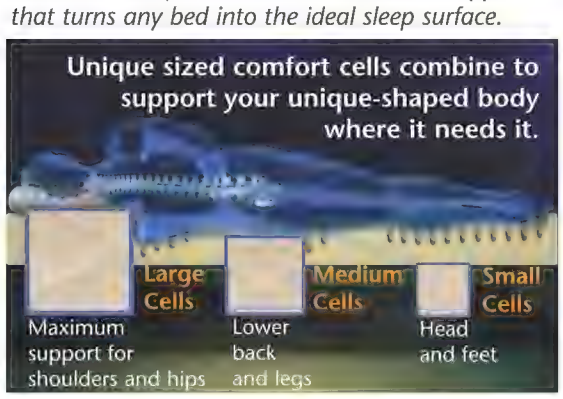

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IT'S ALL ORVILLE'S FAULT.

The Wright brothers' first powered airplane made four short flights at Kitty Hawk, North Carolina, on December 17, 1903. After the last one, as the brothers stood talking, a gust of wind caught the airplane and tumbled it head over heels, cracking it into a jumble of sticks and wire. The Wrights crammed the parts (many of which were scavenged for their future airplanes) into a crate and shipped them home to Dayton, Ohio, where they remained unassembled until Orville rebuilt the *Flyer* in 1928 for display in the Science Museum in London, England.

Orville worked from memory—the brothers had produced little documentation because they always worried about rivals stealing their designs—and without the help of Wilbur, who had died of typhoid in 1912. Could Orville recall the few last-minute adaptations they had made before his first flight? Orville's reconstruction, now hanging center stage at the National Air and Space Museum in Washington, D.C., is only his best guess at the original. We'll never know exactly what flew in 1903.

As a result, anyone who takes on the task of building a 1903 Wright *Flyer* today must also resort to some guesswork, backed by three sources: the Wrights' series of spectacular glass-negative photographs of the airplane, their letters, and a set of blueprints drawn from Orville's reconstructed *Flyer*. Between these sources lies a minefield of missing details about fittings and spacing—issues critical to the delicate design. How a builder chooses to fill in the gaps will determine not only whether the airplane is "accurate," but if it will even fly.

Occupying the exalted position reserved for research aircraft, Ken Hyde's 1902 glider replica undergoes tests in a wind tunnel at NASA's Langley center in Virginia.

IN SEARCH OF THE

And how three builders

JEFF CAPLAN/NASA RESEARCH CENTER

Real Wright Flyer

followed different paths to find it ✻ *by Phaedra Hise*

ERIC LONG (2)

As the centennial of powered flight approaches, three notable teams are hard at work on the problem. Ken Hyde of the Wright Experience is determined to engineer the most accurate *Flyer* possible. The Los Angeles chapter of the American Institute of Aeronautics and Astronautics (AIAA) wants a *Flyer* that is relatively stable and airworthy. Rick Young of Flugmaschine Wright is more interested in the process of discovery, and in re-creating the brothers' working relationship.

As these modern-day builders struggle with the finer points of strut spacing and wing rib construction, each faces the same questions: Is history (and the pilot) better served by accuracy or interpretation? How many risks are worth taking—in the name of authenticity—with a re-creation of something as unstable and dangerous as the world's first airplane?

Rick Young walks briskly to the end of the hangar that is the Virginia Aviation Museum in Richmond. There, the skeleton of his *Flyer* is alone along the far wall, the gleaming wood frame standing tall in a gallery full of its dark metal progeny. A freckled, energetic bundle of a man with pale hair and trim beard, Young is well known in aircraft building circles for reconstructing and flying the Wrights' pre-1903 gliders. He also worked with Ken Hyde and the Wright Experience project, but ultimately broke things off after a few disagreements.

Young plans to test fly his replica in Virginia this winter, provided his diet takes off 30-odd pounds, bringing him closer to Wilbur's weight of 140. Although his schedule puts him in the air before the other teams, Young maintains that such a first is beside the point.

"I'm not trying to experience the first flight," he explains. "I'm trying to re-create what the Wright brothers went through." Young works with an assistant, Grover Cleveland Taylor, in the close way he imagines that the Wrights worked. Young and a Chicago partner are funding the project themselves, "otherwise," he says, "you spend all your time raising money. Funding is all agenda-driven, and you have to do things the way [the sponsors] want." He estimates they will spend a mere $250,000 on their *Flyer*, saving money by following in the Wright tradition of using everyday materials.

"Take an issue like glues," he explains earnestly. "The Wright brothers used horsehide glue. We could try to acquire that, but what's more honest to the experience, getting the normal glue that's right there, or going to the ends of the earth to get horsehide glue?" The Wrights relied on standard off-the-shelf materials, he says. "So use the everyday glue, stay on the normal scale rather than spend a fortune."

Glue is an easy problem to solve. At a table next to the *Flyer*, Young unrolls a set of blueprints the National Air and Space Museum made as part of a *Flyer* conservation project in 1985. Here, the real problems begin.

"If you followed these blueprints, you'd end up with a reproduction of a reconstruction, and I doubt it would fly," he says, pointing to a cross-section drawing of the wing.

"There's hardly a place where the numbers are not wrong in some significant way. Strut placement, places on fittings where distances don't add up to the total, measurements from a detail that don't fit measurements on the layout." When Orville put the airplane back together, Young believes, he knew it was only for display and therefore focused on appearances rather than accuracy. One of the

most problematic structures is the wing rib.

There are 76 ribs, each one shaped like an eyebrow. For each wing, 38 eyebrows line up in a row, and a long, thin wooden spar slides through the wing's blunt leading edge. Another spar slides through the wing about two-thirds of the way back, toward the tapering edge. Fabric stretches across the whole structure to form the airfoil.

Although Orville and Wilbur left many letters about and photographs of the airplane, there is only one description of the rib, and it does not match the ones on the National Air and Space Museum's *Flyer*.

In Orville's sketch, each rib is made from two long strips of wood, held together with small blocks. But on the *Flyer* hanging in the Smithsonian, each of the ribs is cut into two pieces—one larger piece forward of the rear spar, and one smaller, tapering piece aft of the rear spar. Small pieces of steel hold the two pieces together to form a single rib that fits across the spar.

"It's wrong," Young frowns as he punches keys on his laptop computer and calls up a copy of Orville's letter with the rib drawing. "Orville said that it was a single piece of ash. Why would you cut it into two pieces? It makes no sense." Young believes that all of the ribs were broken when the airplane tumbled, and that in the reconstruction, Orville stuck the rear pieces back on by connecting them with the spring steel. Rather than re-create the apparent repair, Young's replica defers to Orville's original sketch, with one-piece ribs made by splitting lengthwise single pieces of ash, each one then carefully fitted onto and slid into place along the two spars.

Although Young is proud of his ribs, he's even more pleased with the process of discovery that led to their design. "Partnering on a problem is the purest way to a solution," he says, waving his arm toward the *Flyer* as Taylor adjusts a fitting on the elevator assembly. "Three people become the tyranny of the majority. But two people will battle it out until the answer emerges. I think Orville—I mean Grover—would agree," he says, then blushes at his slip of the tongue.

Grover Taylor plays Orville to Rick Young's Wilbur as the two men strive to re-create the 1903 airplane at their workshop in Richmond.

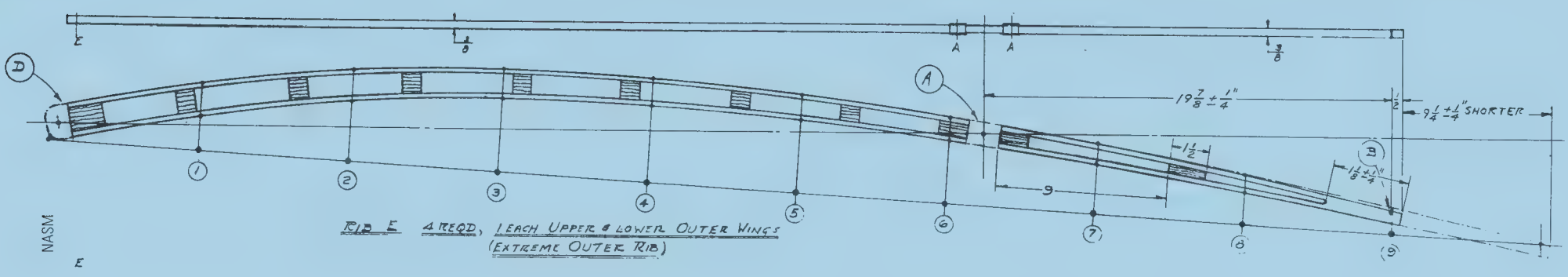
Opposite: Rick Young steadies the skeleton of the replica's wing. To prepare for the project, he first built and flew replicas of the brothers' gliders.

In the office above his spacious hangar in Warrenton, Virginia, Ken Hyde pulls on a pair of white cotton gloves and reaches inside a small cardboard box for a plastic bag. He is a thin man, stooping over as he gently removes a bundle of fabric and spreads it on a table. "It was used for ladies' undergarments," he explains, reverently unfolding the yellowed muslin. What Hyde has in the plastic bag is a four-foot length from the lower left wing of the original *Flyer*. He's got two more in storage, relics from the days after Orville's death when Wright family descendants spread out the fabric on the living room floor in Dayton and cut it up for their inheritance. Hyde winces as he mentions the cutting.

Hyde's dream team of builders is the one against which all others are being measured, not only because Hyde won the contract to fly at Kitty Hawk for the centennial, or because Ford Motor Company and the Experi-

Repair or Redesign?

In 1985 the National Air and Space Museum created a blueprint of the *Flyer* in their care; however, it leaves key questions unanswered. Does the "A" in this drawing of the rib mark a repair or redesign? Is the airplane in the rendering what the Wrights actually flew or merely what Orville reconstructed for display?



"AT THE WIND TUNNEL EXPERIMENTS, THE WRIGHTS WERE NO LONGER LUCKY BICYCLE MECHANICS; THEY WERE SCIENTISTS."

—Ken Hyde

mental Aircraft Association put up hundreds of thousands of dollars to do it, but also because the deep-pocketed backers believe the Wright Experience is building the most accurate *Flyer* possible.

Hyde is as calm as Rick Young is energetic. He speaks with a genteel Southern drawl, as smoothly as you would expect from a former airline captain who has become used to hanging out with corporate bigwigs. His bearing as he stands erect turns his pressed khakis and denim shirt into a uniform. When he gets really excited he might lean forward a bit and lift his eyebrows. He does this when he talks about the Wrights' engineering achievements.

"At the wind tunnel experiments, the Wrights were no longer lucky bicycle mechanics; they were scientists," he says, choosing a sample from among a brace of tiny airfoil designs. He places it on a set of wires in a small wooden wind tunnel similar to the ones the Wrights used and turns on the fan. He smiles as the little piece of tin lifts.

Ken Hyde, like most people who have studied the Wrights' work closely, does not buy into the conventional wisdom that the brothers' relied heavily on the research of Octave Chanute and Samuel Pierpont Langley to achieve success. Hyde's extensive engineering tests show that the Wrights used their own data to conquer controlled powered flight. Their discoveries remain the bedrock of accepted aeronautical formulas and parameters, even today.

"I call this the 'last chance,' " he says. "There are people still alive who sat at the dinner table with the Wrights or flew at their school. We're getting with them to tell the story of the Wrights as engineers and scientists, and the technical data is matching up."

Hyde's *Flyer* is spectacular. Actually, there are two that face each other in the hangar. Their giant wooden skeletons glow as if they had been patiently hand waxed. The first, the EAA's airplane, will fly at the Kitty Hawk centennial after being wind-tunnel-tested relentlessly to measure its lift and drag. The second belongs to Harry Combs, former president of Learjet and co-author of a biography on the Wrights. His airplane will be displayed at the Kitty Hawk museum.

Hyde has spent months reverse-engineering the *Flyer*'s engine and airframe from photographs, letters, and blueprints. But he has one additional source—an impressive collection of original artifacts. These came in handy in replicating the propellers, for example. The only detailed drawings that exist are for the 1911 propellers, which the Wrights planned to mass-produce. To reproduce the props of earlier models, Hyde relied on originals loaned by the National Park Service station at Kitty Hawk, and Marianne Hudec, a niece of the Wrights. He computer-scanned the undamaged half of the 1903 propeller and created its opposite blade to make a digital model for testing as well as a template for carving a duplicate.

Then one fortunate day, Larry Parks, an expert on antique woodworking hand tools and techniques, read about Hyde in the *Washington Post.* He got on his motorcycle and

rode from his home in Warrenton, Virginia, to Hyde's shop to offer his services. In no time Parks had glued up some layers of spruce to make a laminated blank for Hyde. Then he finished it off with a hatchet, spokeshave, plane, draw knife, and gouge. He was able to fit his tools into marks on the original propeller fragment and determine that a no. 2 gouge had done the bulk of the shaping, peeling off luxuriously long ringlets of blonde wood as it sliced into the spruce.

But Hyde doesn't have an original 1903 wing rib, so he puzzled somewhat over the mystery of the two-piece design.

"That spring steel is really a screw up," he concluded. His wind tunnel tests on scale models convinced him that the original spar for the one-piece rib, as drawn in Orville's letter, was too small to support the wing. Hyde believes the brothers recognized that problem at Kitty Hawk, then made a last-minute adjustment without documenting it. They made a bigger spar, he believes, then chopped each rib open and reattached the two sections to the spar with the steel. "Some historians will jump up and down and say 'untrue,' " Hyde says. "But we tested the fabric and there is metal rubbing, which shows [the steel straps] were there on the day they flew in 1903." Never mind that the steel makes for a less-flexible wing, or that it's clearly a bad design on what everyone agrees is an unstable airplane, or even that the Wrights themselves used a one-piece rib on all later aircraft. In the interest of accuracy, Hyde says, he's using the steel. "We re-create the mistake."

Once historians get into this minute a level of detail, it's difficult for them to set limits for themselves. After examining the National Air and Space Museum *Flyer*, Hyde is convinced that Orville's reconstruction job holds a secret message, one that seems to support Rick Young's one-piece-rib theory. "[Orville] was very careful to put different kinds of wood in the repairs," Hyde says. "In the blueprints, in some ribs you'll see spruce in front, ash in middle, and spruce in back. He was saying, 'This is not original.' " Hyde doesn't like to be called obsessed, but the fact is that no average aircraft home-builder could create this airplane.

And therein lies another discrepancy. Hyde's work is pristine, but the Wrights' airplane was surprisingly crude. It was built quickly during the Victorian era, when manufacturing standards for many of the off-the-shelf materials the Wrights used were somewhat lax. The fabric, for example, contains threads with large differences in diameter. Since most modern fabrics use more uniform threads on today's high-speed machinery, it's almost impossible to replicate the coarser material the Wrights used. The fabric was not "doped," or coated with paint or other smoothing and stiffening agents, so the weave's characteristics and permeability are key to the airplane's performance. And yet, to be absolutely accurate, a replica must be found. It is one of those myriad missing details that worries Hyde, Rick Young, and the AIAA team as well.

Lest someone forget that the centennial is, after all, about flight, one team is building a reminder. "The Wrights set out to build an airplane that would fly," says AIAA project engineer Fred Culick, a research fellow at the California Institute of Technology in Pasadena. "You can agonize over the details but nobody will ever know, so you might as well guess and build it the way it ought to be built." In other words, for this group, it's not a matter of producing the most accurate airframe, but making it capable of taking to the air, and safely.

It's no small matter. According to the handful of pilots who have flown one, the flight characteristics of the *Flyer* are very squirrelly. The airplane is unstable and ultra-sensitive to pitch changes. "You fly it enough and you're going to break your neck," warns Ken Kellett, one of the few pilots aside from the Wrights who have made and flown a 1903 *Flyer*. He built his when he was 23 and living in

ERIC LONG (4)

Hyde (top) believes the imprints on the original yellowing muslin prove the Wrights used steel to bolster the ribs. Larry Parks (above) uses antique tools to craft a replica of the 1903 propeller.

Opposite: Hyde runs a meticulous shop in Warrenton, Virginia (top). A portion of the sliding hip cradle (below) rests across an ash rib on Hyde's Flyer.

In 1978, Ken Kellett (left) spent 4,500 hours building his first Flyer *(far left).*

"THIS PLANE IS UNSTABLE. ONCE IT COMES OFF THE TRACK, IT'S GOING TO DO WHAT IT WANTS TO DO."

—Ken Kellett

Colorado, and he finished it just in time to fly it at Kitty Hawk in 1978 for the 75th anniversary of controlled, powered flight. He flew it at Kitty Hawk again for the 80th anniversary.

Like the Wrights, Kellett first built and flew replicas of the 1900 and 1902 Wright gliders. That training is important to success in the *Flyer*, says Rick Young, who has built and flown reproductions of every Wright glider. "There are things that you wouldn't discover on a simulator because you don't have the static and inertia component…of attitudes and acceleration." In simpler words, you're not really moving when you're in the simulator chair. Hyde's team will also train on his 1902 glider. "That's where the Wrights got all their training from, and there's really no substitute," he says.

Kellett now builds and restores airplanes for Kermit Weeks' Fantasy of Flight Museum in Polk City, Florida. He spent nearly a year and $3,000 building his *Flyer* in the mid-1970s. The main challenge in creating an accurate reproduction, he remembers, was to make the thing as rough as the original. "Ken Hyde does exquisite work," Kellett says. "But the undercarriage nails on the original are hammered over on the backside. I want to see him do that, bang a nail through there and smash it flat on the other side. I couldn't bring myself to do it. I can't make an airplane that crude. People would slam my work."

Kellett built his two-part ribs according to the blueprints because he hadn't seen Orville's sketch. He dismisses the wing rib as the least interesting problem the airplane poses. He found something else to obsess about. "Everyone wants to take one tiny thing and microscope it," he says. "My microscope was on the canard assembly." The two-surface elevator on the front of the *Flyer* "physically will not take the movement it is supposed to do," he found. "The geometry doesn't work." Kellett's elevator "binds up," he says, instead of moving smoothly. In 1985, Kellett was invited to visit the National Air and Space Museum during its conservation of the 1903 *Flyer*. He manipulated the original elevator controls, he says, and found that they bound up the same way.

Wright experts don't consider Kellett's *Flyer* absolutely accurate because he made modifications to the airframe and his engine is lighter and more powerful than the original. Kellett argues that the modifications fall into the gray area every builder will have to negotiate, and that between his greater body weight and his running the engine at lower rpm, he came close to matching the *Flyer* performance. Accurate or not, Kellett has logged 23 flights in his, for a total of four minutes (the Wrights had just over a minute between them). "This plane is unstable," he warns. "Once it comes off the track, it's going to do what it wants to do."

Fred Culick agrees, and as the first pilot in line to fly the AIAA model, he's taking steps to minimize the risk. The AIAA team has studied data from wind tunnel tests of two subscale models built in 1980 and a full-scale airframe replica built in 1999. The team won't fly that one, however. "The airplane is very seriously unstable in pitch and roll, very unstable directionally," Culick says. "Well, we're making a few changes."

Jack Cherne, a longtime aerospace engineer and the AIAA Wright project director, explains that the team is changing the airfoil

CHAD SLATTERY (4)

More Flyers

To celebrate the centennial of powered flight next year, more than 25 Wright *Flyer* replicas, built to varying degrees of accuracy and airworthiness, will be hung in lobbies and paraded through towns. A select few will even fly with some brave pilot in the hip cradle.

Master woodworker and pilot Nick Engler of West Milton, Ohio, re-created all of the Wrights' gliders under the auspices of his nonprofit business, the Wright Aeroplane Company, before attempting the 1903 *Flyer* this year. He's also working on a reproduction of the 1905 model. He plans to fly all the aircraft at an airshow in Dayton, Ohio, in July.

In a piece of derring-do that the Wrights would have admired, Lieutenant Commander Klas Ohman, a pilot for the U.S. Navy, will fly Engler's 1903 replica off the deck of the USS *Kitty Hawk* in Tokyo harbor this winter. The aircraft carrier will be underway to simulate the wind conditions that the original needed in order to fly.

Dana Smith, a pilot and restorer in Limerick, Maine, who ran an aviation maintenance technicians school for 25 years, bypassed the 1903 aircraft for what he calls "safer, more stable" designs. He has been flying his replica of a Wrights' 1909 airplane for four years and has built three other models, including the Wright Model R, which in 1910 could fly 70 mph. He will fly several this May at the Festival of Flight in Fayetteville, North Carolina.

Other *Flyer*s created for takeoff include a reproduction from Carnesville, Georgia, built by John Reynolds and slated to fly at the Atlanta Motor Speedway in August, and a replica by engineering students at Utah State University for Dayton's celebration in July. And on December 17, 2003, the Wright Redux Association of Glen Ellyn, Illinois, will launch its machine from the lawn of Chicago's Museum of Science and Industry.

—Roger A. Mola

shape slightly, and adding more power in response to the wind tunnel results. The 40-horsepower engine contrasts sharply with the 10 to 12 horsepower that the Wrights' engine generated, so they must beef up the airframe. "We're making sure the plane can handle the added power," Cherne says.

The AIAA team isn't bothered by the accuracy of details. The members are not obsessing about horsepower, or finding the definitive strut placement or determining the exact bracket weight. "Those aren't the problems the Wrights were obsessed with," says Culick. They wanted to get an airplane into the air and fly it, he says, and that is exactly what AIAA plans to do.

Cherne points out that the team hopes to fly its *Flyer* regularly at airshows. "The idea is to give the impressions of the first flight," Culick says. "Take off, fly low, land safely, don't bust the airplane. For that you're not going to worry about a quarter-inch on the length of a strut."

The airplane will look like a Wright *Flyer*, and will have most of its flight characteristics. It will be, Culick says, "not what you'd call a safe plane, but not as unsafe as the Wrights found out themselves."

The AIAA Flyer *will leave its home in Los Angeles (below) this summer to tour the country. Right: Jack Cherne (at right) and Fred Kulick disassemble it for travel.*

Today, the original 1903 Wright *Flyer* floats silently above the entry of the National Air and Space Museum keeping its secrets. The white muslin-covered wings and fragile-looking wooden spars barely seem to support the mannequin lying on the lower wing. Millions of visitors have looked at this symbol of craftsmanship, courage, and ingenuity with admiration and awe.

But Ken Hyde, Rick Young, and the engineers of AIAA see instead a confusing puzzle of wrong fittings, misplaced nail holes, uneven struts, a faulty elevator, and two-piece wing ribs. The questions that it raises are maddening. We know that it flew, but the details are a mystery that may never be solved. Perhaps that is the best monument to the genius of Wilbur and Orville Wright.

"TAKE OFF, FLY LOW, LAND SAFELY, DON'T BUST THE AIRPLANE. FOR THAT YOU'RE NOT GOING TO WORRY ABOUT A QUARTER-INCH ON THE LENGTH OF A STRUT."

—Fred Culick

White Elephant

Russia's Buran space shuttle made it into orbit only once, and the pilots who trained to fly it are still bitter.

by Tom Harpole

When Victor Zabolotsky, a test pilot who once trained to fly the Soviet Buran space shuttle, thinks back on the project that dominated his working life for nearly a decade, he figures some good came of it despite Buran's cancellation. "We lose three or four test pilots every year, so wasting all that time probably helped me survive that career," Zabolotsky says wryly. Before and after his years training for the Buran, Zabolotsky flew more than 70 kinds of aircraft. "My daughter, Margarita, was recruited to be a cosmonaut," he continues. "And after what she observed—my distrust of the bosses and the way they treated me—she declined to join the cosmonaut corps. So the Buran may have kept me alive, and it helped my daughter find a career with a future."

Like most Russians who worked on the Buran, Zabolotsky is still indignant about the experience. Pilots, scientists, engineers, and the technicians who built the vehicle all speak candidly, if a little diffidently, about what they see as a sophisticated, spectacular failure. It became for them the perfect symbol of a space program that had lost so much confidence that, at the behest of the Soviet military, it copied a U.S. vehicle for no reason other than to keep up with the competition.

But seen another way, Buran was an impressive technical accomplishment. In fact, you could say the Soviet spaceplane, which reached Earth orbit just once in 1988 and never returned to space, succeeded beyond all expectations and failed dismally—both on the same day.

We are ascending in a dimly lit elevator inside the Moscow headquarters of the Molniya Research and Industrial Corporation, once the Buran's ultra-secret design bureau. Someone whispers, "Amerikanski journalist, it feels weird having you here." I look up at the red numbers flashing enigmatically above the door—3…8…8…9—then back to 3 as the door opens on the 5th floor. I wonder if the numbers mislead passengers for reasons of secrecy, or if this is just one more thing in Russia that doesn't work.

Like NASA's space shuttle, Buran had its predecessors. Soviet space engineers had played with designs for mini-shuttles as far back as the 1960s. But it wasn't until the United States decided in 1972 to build a spaceplane that its cold war rival took serious interest. "With two countries pointing thousands of ballistic missiles at one another, every move made toward de-

ROGER RESSMEYER/CORBIS

The Soviet military wanted Buran (shown in its hangar) solely as a means to counter a perceived U.S. threat. When the cold war ended, so did the Soviet shuttle program.

veloping space technology was regarded by the other as having military meaning," recalls Alexander Bashilov, a 52-year-old aerospace engineer who is today Molniya's director general. "In the early '70s, when the U.S. began developing the space shuttle, naturally we assumed it would be used to deliver nuclear weapons, or as a sort of space pirate ship for shooting or stealing Soviet satellites. We had no choice but to respond." So Buran, which means "snowstorm," was born.

In his 1997 biography of Soviet rocket pioneer Sergei Korolev, U.S. space historian James Harford writes: "The USSR's conviction that NASA was cloaking military space ventures in civilian clothing led to a misguided copycatting of the U.S. space shuttle." NASA had actually conceived its shuttle as a way to reduce the cost of launching both military and civilian payloads into space. But according to Efraim Akim, a veteran Soviet space mission designer interviewed by Harford, the Soviets

More than 150,000 people worked on the project in the 1980s. No one can say for sure how much it cost.

AFP PHOTO/ALEXANDER NEMENOV/CORBIS

saw right away, based on their own calculations, that NASA's cost projections were wildly optimistic. So they figured there must be another motive. Soviet military planners noted with alarm that a shuttle taking off from a planned launch pad in California could reach orbit and deliver a first strike against Soviet missile silos within minutes. By the logic of the cold war, the Russians had to have a shuttle too. Thus began the most wasteful venture the Soviet space program ever attempted.

With the same intensity that characterized the rivalry between the two superpowers, ministries within the Soviet Union fought one another to get a piece of the project and shape its direction. At its zenith, the Buran program employed more than 150,000 workers at more than 50 factories.

Stepan Mikoyan, the 80-year-old nephew of famed MiG jet designer Artem Mikoyan and himself a World War II veteran, test pilot, and aircraft designer, witnessed the waste firsthand as Molniya's flight test director for Buran. Even today, no one can say exactly how much the vehicle cost to develop, he says. "The Central Committee would decide to do something like the Buran and then just throw rubles at it until it was done," Mikoyan recalls.

Despite its resemblance to the U.S. shuttle, Mikoyan says Buran had one key difference that helped drive up its price tag—its ride into space was the massive Energia rocket. Capable of lifting more than 100 tons to a 110-mile circular orbit, the Energia was the brainchild of renowned rocket designer Valentin Glushko, general designer for the RSC Energia company. Twice awarded Hero of Socialist Labor medals, Glushko had been a major figure in Soviet rocketry since before World War II. Reportedly, his only real interest in Buran was that it was heavy enough to prove that Energia could lift more weight into space than any rocket yet developed. "The most important aspect of rocket design," Glushko once bragged, "is the engine. A stick will fly into space with the right engine tied to it."

Though Glushko considered Buran simply a dummy payload for a rocket that could someday be used for more glamorous expeditions, such as to the moon or Mars, the booster and the spaceplane wound up sharing the same fate. Just as Buran had no clear purpose other than to keep pace with the Americans, Energia had no job other than to lift the shuttle—or at least no job that a country going through a painful economic and political transition could afford. Says Mikoyan, "The chance of many such rockets appearing in Russia's economic condition in the early 1990s was very small." So Energia was launched only twice, and had no role after Buran's debut in 1988.

Capping its one and only spaceflight, made unpiloted in 1988, the Buran, escorted by a MiG-25, landed at Baikonur.

SOVFOTO/TASS

Even before its lone spaceflight, there were plenty of signs that Buran had no future. "No other design agencies were developing satellites that could fit in the cargo bay," says Igor Volk, the veteran cosmonaut who piloted Buran during its early atmospheric tests. "The main designers and builders couldn't even decide whether to call it a spaceship or spaceplane. It was a perfect metaphor for the end of that period of stagnation."

And yet, during the 1980s, the program continued at full throttle. A total of eight Buran "analog" vehicles were built at Molniya. Final assembly of these full-size models was undertaken a couple blocks away, at the Tushinskiy Mashinostroitelny factory. One analog, used for atmospheric and landing tests, was outfitted with turbojet engines that enabled it to take off from a runway. Two orbital models were loaded on barges and floated down the Moscow River to the Zhukovsky Aerodrome, where they were piggybacked onto a 3M-T cargo aircraft for transport to the Baikonur launch facility. The remaining analogs were used at Molniya for stress, vibration, and temperature tests.

Mikoyan, a compact, handsome man with a full head of wavy white hair, smiles and admits that the Soviet designers at Molniya learned everything they could about the U.S. shuttle as they developed their own version. Even though the recipe for ceramic tiles that protected parts of the vehicle from the heat of atmospheric reentry was "a problem that was solved slowly," he says, the thermal protection system designed at Molniya was remarkably similar to NASA's. "In other respects we studied and surpassed the shuttle design in such components as ejection seats for the flight crew," Mikoyan says. These were designed to work for pressure-suited cosmonauts up to an altitude of about 30 miles.

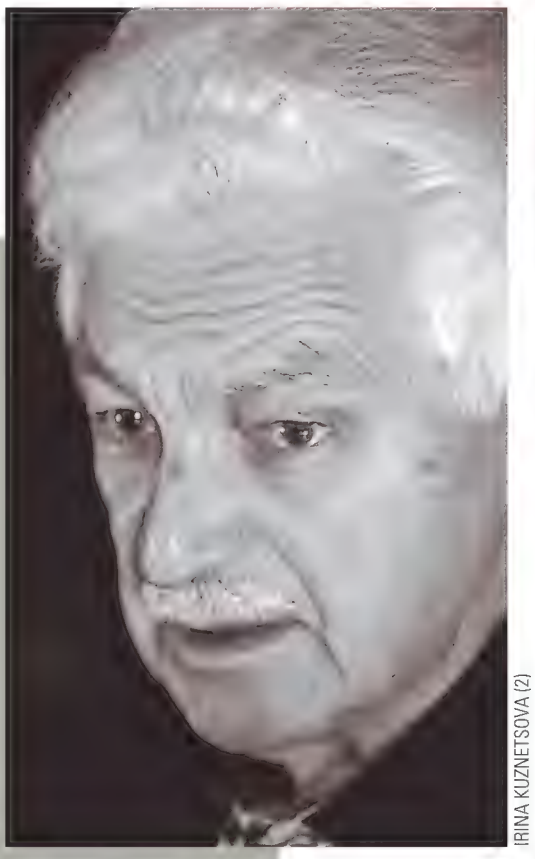
That the shuttle and Buran look nearly identical proves only that any group of aeronautical engineers will arrive at similar designs for aircraft with similar purposes, say the Russian designers. "The Ilyushin and Boeing passenger jets look alike to the uncritical eye," said Gleb Lozino-Lozinsky, the former director of Molniya, who worked on Russian spaceplane designs in the 1960s. "That doesn't mean they were copies of each other."

Lozinsky passed away last November at the age of 91, but when I met him in Moscow a few months earlier, he looked sword-thin and fit and was still walking 40 minutes to work every morning. He was spending his days designing yet another reusable spaceplane, this one to be launched from an "aerial cosmodrome"—an Antonov An-225 Mriya cargo aircraft.

On the wall behind Lozinsky's desk hung tinted photographs of Vladimir Lenin and Anastas Mikoyan, Stepan Mikoyan's father and a lifelong Communist party member and Politburo figure. "Those two men made a man out of me," Lozinsky said. He survived the purges of Stalin and navigated the intricacies of Soviet cold war politics. "In the days of Korolev," he said, his pallid face reddening, "we had one boss. Everyone took their orders from him, and programs progressed swiftly and logically. When we lost sight of efficiency, we lost our ability to justify this expense." A strong personality, Lozinky was not shy about dispensing advice. "Americans have lost sight of efficiency," he warned. "They should be looking at an aerial cosmodrome for less expensive launches."

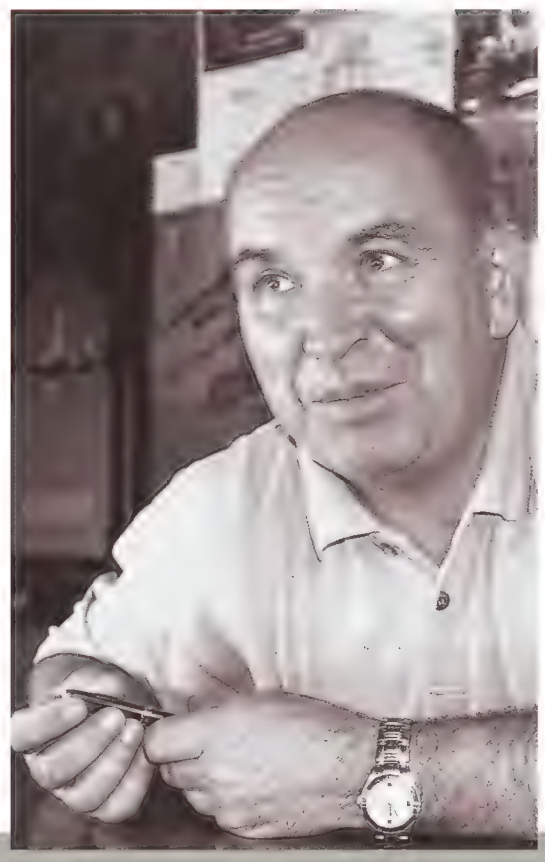
A gentle rain outside his open window began lashing down a bit harder. With the agility of a 40-year-old, he got up, crossed the room, passed his hand across the windowsill to feel for moisture, and decided to leave the window open. He looked up at the dingy Moscow sky and made a wish for the future. "Efficiency," he said, "should be considered above all else as we develop more vehicles for space travel."

"Hypocrites and fools from a dozen ministries ran the Buran program. It was an honor with very little real meaning attached to it."



IRINA KUZNETSOVA (2)

Stepan Mikoyan: The likelihood of building many Energia rockets to boost Burans was "very small."



"We lose three or four test pilots every year, so wasting all that time probably helped me survive that career."

Igor Volk holds the distinction of being the only Soviet to orbit Earth and not be rewarded with a car. His oft-proffered opinions on the problems with the Soviet space program cost him the new black Volga four-door he would have received after the 1984 Soyuz T-12 flight. He was, however, named cosmonaut-in-charge of Buran flight testing. "Hypocrites and fools from a dozen ministries ran the Buran program," Volk asserts. "It was an honor with very little real meaning attached to it." Then he adds, as if trying to dismiss the memory: "I've flown many more interesting aircraft than the Buran." Volk's nickname is "Red Wolf." A ruddy, affable, and articulate man, he is still ready and willing at age 65 to continue his career as a test pilot. But, he laments, "there are no new planes to test."

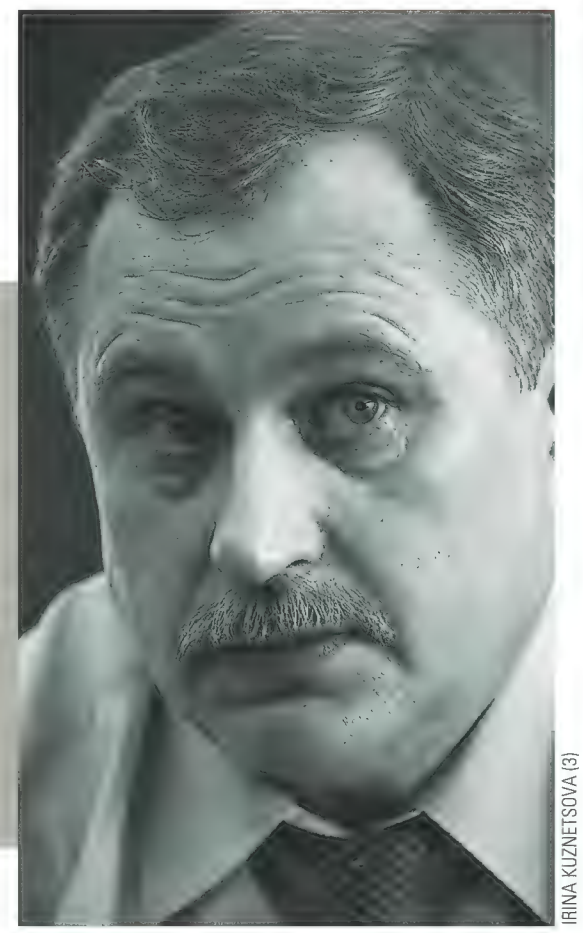
During his career Volk performed hundreds of dead-stick landings in all kinds of weather and all kinds of aircraft, sometimes in direct defiance of his superior's orders. He never ejected from or lost an airplane. His experience in flying more than 120 types of aircraft made him the leading candidate to test fly the Buran to evaluate how it glided, approached, flared, landed, and rolled out.

Volk knew before most people working on the program that it was doomed. He recalls a drunken boss exclaiming to him at a social gathering in 1988, "It would be great if we had an accident on the orbital flight. That would give us a good, plausible reason to cancel the program." Volk says now that he never fully trusted the amalgam of components contributed by different ministries and organizations. He was only the 11th person to be awarded the Revoredo Trophy for outstanding contributions to aviation, and his vast experience with prototypes made him worry about the Buran's cockpit. After one early test, he remembers, he couldn't open the hatch and had to exit through the vehicle's fuel tank. The technical problems would always be solved, but his uneasiness remained.

The ignominy of spending years wringing out a vehicle designed to eliminate human input still raises Volk's ire. He flew the full-size atmospheric prototype, which was outfitted with four 18,000-pound-thrust Lyulka jet engines, on more than half of its 24 flights. The first landings were manual. Then, over successive flights, Volk gradually relinquished control to the auto-land software, until the last few landings were accomplished by computer alone. At that point, Volk says, his interest in the Buran project waned.

For the people who worked on it, this was another of the program's bitter ironies. The first contingent of nine cosmonauts assigned to Buran in 1977, a year before NASA hired its first shuttle astronauts, included some of the

Molniya director Alexander Bashilov (right) says the Soviets "had no choice but to respond" to the U.S. shuttle, which they assumed was a bomber. His predecessor, Gleb Lozino-Lozinsky (left), decried Buran's waste.



IRINA KUZNETSOVA (3)

Unlike the twin booster rockets used for NASA's shuttle, Buran's Energia booster was a total throwaway.

SOVFOTO/TASS

most accomplished test pilots in the Soviet Union—and, in the case of Igor Volk, the world. But their job was to serve as understudies in a vehicle designed to require no human input.

Most of the first Buran cosmonauts were employees of the Gromov Institute, outside Moscow, Russia's premier center for flight research, while others came from the Institute of Experimental Flight, a branch of the Ministry of Defense. Volk and Rimantas Stankiavicius, who also was picked in 1977, were the two main pilots for the series of atmospheric flights conducted between 1985 and 1988. Three teams of two pilots made 24 short-approach-and-landing flights in a full-scale Buran prototype. But when the vehicle finally reached orbit strapped on the back of the giant Energia rocket, the pilots stayed home. And that may stand as Buran's single unique accomplishment: It returned from its two orbits and landed like a conventional airplane, controlled entirely by computers. The Buran's auto-land software, though kluged together, worked perfectly on its one and only space mission.

Sergei Krikalev became a cosmonaut in 1985 and has gone on to become perhaps the most experienced space traveler alive (see "The Captain, the Pro, and the Fighter Pilot," Feb./Mar. 2000). He recalls watching the Buran's flawless launch from the Baikonur cosmodrome. November 15, 1988, dawned with a storm front from the Aral Sea moving across southern Kazakhstan. Energia's launch had been put off several times, and officials declared that this would be the day, despite the clouds, wind, and 40-degree-Fahrenheit temperature. Liftoff occurred at 6:00 a.m.

About three and a half hours later, the Buran landed on a specially built runway north of the launch pad. "As a pilot, I guess I was a little jealous when it emerged from beneath the cloud cover on its final approach," Krikalev says, grinning. "I thought the computers would get it to, say, 4,000 meters and then it would drift away. It touched down within a meter and a half of the center stripe and stayed within a meter of the center of the runway until it stopped. It looked as though a good pilot was at the controls." High praise from a cosmonaut who also happens to be a former world champion aerobatic glider pilot.

Krikalev had, like many of his colleagues working on Buran, worried about the accuracy of the first landing. The auto-land software had been developed at five independent organizations, each of which had written a program to command the Buran to (1) leave orbit, (2) descend to an altitude of 60 miles, (3) glide through the atmosphere at an altitude of 13 miles, (4) make its approach to a microwave- and telemetry-equipped airstrip at Baikonur, and (5) flare, get the landing gear down, and roll out. Given the potential for something to go wrong, "it was oddly satisfying to see it land as perfectly as it did," Krikalev says.

But Victor Zabolotsky, who copiloted Buran on its last taxi test in 1989 and is now president of the Russian Federation of Amateur Aviators, disputes the common claim that the landing was successful, saying that the landing approach the computer chose at Baikonur was "stupid, with a high percentage of risk. Most amateur aviators would not have considered that approach." An animated speaker with deep creases above his right eye and a scar over his left eye, Zabolotsky says that on a scale of one to 10, he would give the Buran landing a four. "There was a crosswind at about 30 degrees to the airstrip that had been blowing

SOVFOTO/TASS (2)

Viktor Afanasyev tested Buran but ended up flying a Soyuz vehicle into orbit.

since the launch," he recalls. "A normal pilot would have kept the crosswind on the right wing, then simply made a left turn across the wind and an approach and landing with the crosswind on the left wing. The Buran computer chose to make a left turn over the center of the runway, then a hard descending right turn into the crosswind for final approach and landing.

"When it emerged from the clouds, it had a close encounter with the MiG-25 escort flown by [test pilot] Magomet Tolboev, who had intercepted the Buran at 9,000 meters [29,000 feet] above the cloud layer. He lost it in the clouds, then had to take an evasive maneuver under the clouds when the unorthodox pattern the computer selected flew the plane into airspace where no human pilot would have anticipated encountering it."

Zabolotsky nonetheless admits, grudgingly, that there was a logic in using the auto-land system. No Soviet space vehicle had ever been allowed to fly with people until it had conducted two successful orbital demonstration flights. The Buran program was simply complying with a rule going back to Korolev's days. Faced with the same dilemma, NASA had waived its own safety rule, and on the first shuttle mission, John Young and Robert Crippen rode an untested rocket. To this day, they are the only astronauts to do that.

Zabolotsky doesn't want to concede too much, however. "There was the capability [on Buran] to override the computers in an emergency," he says. "I believe that option would have been exercised, often. I don't believe a pilot like Igor Volk, who could dead-stick land every plane we ever made, was going to sit idly as a computer aims his plane at a runway."

When Russian president Boris Yeltsin quietly canceled the Buran in 1993, the move came as no surprise. Even people who devoted careers to the program say it was the right decision. Although a richer country might have found the Buran a versatile tool for military or civilian applications, by the late 1980s Russia could no longer afford cold war gamesmanship, having bankrupted itself trying to keep up with the U.S. arms program.

Like other relics of the Buran program, the runway that was built for the spaceplane ended up in a state of decay in the 1990s, although it has since been revived as a runway for commercial cargo flights in and out of Baikonur. In the 1980s, though, Buran's landing strip was a technical marvel. Designed to minimize wear and tear on the vehicle, it used a high-grade reinforced concrete, which had to be polished to an unprecedented degree of smoothness—varying by no more than a tenth of an inch every 10 feet—by diamond polishing disks developed specially for the task.

The design and construction of the runway were military operations overseen by retired major Vitaly Zhilo, who remembers "working enthusiastically" for eight years on the Buran project. "There was a certain prestige for those who were working on the space race," Zhilo recalls. "It is rewarding to know you are building something as unique as a 4.5-kilometer [2.8-mile] runway for your country's spaceplane."

A movie-star-handsome man at 58, Zhilo regrets that many thousands of people had no idea what they were building in the factories. And by the time they found out, the excitement was long gone. "After the first [Buran] flight, when the point was made that we could do it, we also knew that the money would dry up immediately. We knew that Progress rockets could deliver payloads to orbit for ten times less expense," Zhilo says.

I ask Zhilo to join me for a visit to Gorky Park in Moscow, where one of the Buran vehicles is on permanent display, but he declines. "It's too expensive. It's too sad." He pauses. "We were first with a dog in space, then a man, then a woman, then a spacewalk, then two vehicles docking together. All Soviet people were so proud of winning the space race. But by the time the Buran was ready to go, ordinary people had too many problems just trying to feed themselves. "

Of all the Buran vehicles that were built, perhaps the most poignantly visible is this full-scale analog, used for

The collapse of a hangar roof at the Baikonur cosmodrome last May destroyed the only Buran vehicle ever to reach space.

stress and vibration testing in the early 1980s. It now resides with a group of carnival rides in a far corner of Gorky Park. The Buran is the least visited of the attractions, says Yuri Smirnov, the caretaker for the display. The spaceplane was brought to the park on a barge going down the Moscow River in 1995, then lifted and set in place by two huge cranes. A Coca-Cola machine and some plastic tables and chairs are arrayed under the starboard wing. For 160 rubles ($5.50) you can climb the stairs and sit in the cargo bay, which is fitted with seats that tilt downward when the half-hour program starts.

The show begins with 10 minutes of rocket engine noises thundering from large speakers that flank a six-foot-square screen; meanwhile, the projectionist waits for late ticket holders. When she finally rolls the film, we see the dawn launch at Baikonur. Then an interior shot of the cockpit shows two "pilots" flying the ship, even though Buran's lone orbital spaceflight was unmanned. A voiceover interrupts to advise the audience that for the equivalent of about $10, they can have a star named after themselves or a loved one. Certificates are for sale at the kiosk under the wing after the show.

The rest of the movie is all science fiction. The Buran crew shoots down a meteor that will destroy Earth. A fictional docking with the Mir space station is depicted with a puffy-faced cosmonaut, Gennady Strekalov, waving amiably at the camera. Next we see a spacewalk to fix an aft thruster problem that could prevent the shuttle's reentry. Then comes dated footage of Houston's mission control; the guys at the console, their hair covering their ears, all flash thumbs up. The film reverts to actual footage of the Buran landing, and a woman's voice again reminds the audience to buy a star from the girl at the bottom of the steps on our way out. As we head down the stairs, we can see a nearby pirate ship ride swinging 60 people slowly back and forth by the Moscow River.

"Ninety-five percent of the people who see that film treat it as history," says Vladimir Mozgovoy. "Too bad, it's mostly school groups who still visit the Buran, and they're getting a totally false history. But I guess they're seeing fragments of truth about the last statement of an empire." Mozgovoy, a portly man wearing a Mafia wannabe's black leather jacket on a hot afternoon, introduces himself as "technical director" of the attraction. "People who worked in the Buran program sometimes visit and they almost always leave with tears in their eyes," Mozgovoy says. "I hate that. But fortunately, most of the people who worked on it are retired and can't afford to come here." He corrects himself: "Last year, Anatoly Artsebarsky, another of the cosmonauts who trained for the Buran, had sort of a party for his friends here. In the middle of the movie, [when Artsebarsky] appeared in his spacesuit, they had a few toasts."

In addition to the Buran attraction at Gorky Park, two full-size Burans and three Energia rockets resided until very recently in enormous hangars at Baikonur. Last May the roof of one hangar collapsed, killing eight people and destroying the only Buran vehicle that had made it into space. A couple of years ago, the model that Igor Volk flew was put on a barge and shipped to Australia for the Olympic games. "We were told that the analog was rented to the Australians for the games," Volk says. "In fact, someone sold it to the Australians and we'll never see it back in Russia." He laughs derisively when I ask who sold it. "The bosses who sold it don't want us to know anything else about that project." He shrugs, as if to say he isn't much interested in finding out either. "It's over."

Ignominious end: A Buran in Moscow's Gorky Park draws few tourists.

SOVFOTO/TASS

Resto

Going the Distance | Consolidated PBY-

Floyd Bennett Field, a Brooklyn, New York airport that saw its glory days in the 1930s, is now virtually abandoned save for a buzz of activity in Hangar B, where volunteers for the Historic Aircraft

NASM NEG#86-10312

Restoration Project (HARP) are reassembling a handful of vintage aircraft. The most unassembled and the highest priority is a Consolidated PBY-5A Catalina, a large amphibian with a 104-foot wing, out of which protrude a pair of radial engines, giving the airplane a bug-eyed look.

PBY-5As don't have speed (they lumber along at 117 mph) and they are not exactly nimble (fully fueled they tip the scales at 35,000 pounds), but they do have a range of more than 2,500 miles, and that's why they were widely used as rescue aircraft and patrol bombers during World War II. Whether hunting down German and Japanese naval vessels or plucking Allied aircrews out of the ocean, Catalinas were a steady presence throughout the war. Twenty-hour missions were not uncommon for the PBYs' seven- to nine-man crews, and their tirelessness paid off: On May 26, 1941, the crew of a British Royal Air Force Catalina spotted the German battleship *Bismarck* sailing in the north Atlantic and reported its position to the Royal Navy, which sank it the next day.

Catalinas also kept busy in the Pacific as well. There were several U.S. Navy squadrons known as the Black Cats, who flew night missions to disrupt Japanese shipping operations in the Solomon Islands. In PBYs painted black for camouflage, Black Cat crews flew with lights out, unleashing 500-pound bombs on the targets below. To further terrorize Japanese sailors, the Black Cats dropped empty beer bottles, which produced an unsettling whistle as they fell.

Irving Krasner, who is helping to restore the PBY-5A, enlisted in the U.S. Navy in June 1942 and ended up piloting PBYs for Fleet Air Wing 14. Ensign Krasner was assigned to North Island, off San Diego. "Our patrol region encompassed the whole South Pacific," he recalls, but in 1943 and '44, he frequently flew on anti-submarine patrols to San Francisco and back at night. As for the airplane, "it was very stable," says Krasner. "It didn't have hydraulic controls, so we had to use a lot of muscles to fly it." And it didn't have flaps either. With a landing speed of just 60 mph, it didn't need them.

The restoration crew, led by HARP executive officer Richard Postel, knows little about the PBY's previous life, except that the craft had been flown in Brazil. Several instruments are in that country's language, Portuguese, and cartoons of a flying turtle in fading paint on either sides of the vertical stabilizer read "Devagar Mas Ciego Là"—"We're Slow But We Get There."

WIDE WORLD PHOTOS

HENRY JOSEPH

U.S. Navy PBYs flew in every theater of the Pacific War, their long range ideal for patrolling the waters from the Solomon Islands to the Aleutian Islands (top). Consolidated manufactured 4,000 PBYs (above). Volunteers have yet to reattach the tail (right) to the fuselage (opposite), which has been stripped and coated with zinc chromate, an anti-corrosion preservative.

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5A Catalina

Before the PBY became a HARP project, it was overseen by the U.S. Marines based in Cherry Point, North Carolina. It had just barely survived a hurricane. "The Marines loaded the wings with water for ballast but it flipped over anyway," says Postel. "The wings were sheared off—the whole thing was a wreck."

A typical PBY carried five machine guns: two .30-calibers in the chin turret, one .30 aft of the step, and two .50s in large side blisters. The HARP Catalina has no such blisters and chin turret; they were probably removed when the airplane was outfitted with bench seats and a toilet for transporting passengers. Postel isn't yet sure if his team can afford to replace the blisters—they cost $20,000 each—but Krasner may well buy and donate a chin turret.

The volunteers have been working on the PBY for four years, and they expect it will be seven more before it's ready for static display at Floyd Bennett Field. If you have any information on this aircraft, write to Floyd Bennett Field Hangar B, Brooklyn, New York, 11234-7097, or call (718) 338-5986.

—Phil Scott

HENRY JOSEPH (2)

Dorothy Tuminello runs the canteen that provides refreshments for the restoration team, including her son Murphy (center) and project director Richard Postel.

Walk out on the ramp, past the static displays, the remote-controlled-model tent, the Marine recruiting stand, and the car show, on across the drying grass to where the flying exhibits were parked, then around the corner at the tail of a B-25. There they are, all gleaming deep blue and jutting propeller blades. It's the Corsairs.

CorsairFest

Have you ever seen a prettier Marine?

BY LARRY LOWE PHOTOGRAPHS BY ERIK HILDEBRANDT

Inspired by an event for P-51s in Florida in 1999 (see "Mustang Mania," June/July 1999), last September the Indianapolis Air Show assembled as many flyable examples as possible of the Chance Vought F4U Corsair, a hog-nose, bent-wing, big-ass Mack truck of a fighter that raged across the South Pacific during World War II and later in Korea. Between 1941 and 1952, some 12,500 F4Us rolled off the assembly line. Today there are fewer than 30 Corsairs left, and only 10 to 15 are flyable in the United States. There were only seven of those at the Gathering of Corsairs and Legends reunion at Indianapolis.

Across from the visitor area, in a large red-and-white-striped tent, were some old men wearing baseball caps adorned with unit identifiers like "VMF-223." These were the Legends, the men who flew the F4U in combat.

Also prowling the grounds was Robert Ginty, who came all the way from Dublin, Ireland. Ginty played T.J. Wylie in the 1976–'77 television series "Black Sheep Squadron," which was based loosely on the memoirs of Major Gregory Boyington, the commander of the legendary Marine VMF-214 Black Sheep squadron. T.J. was the young, somewhat naive flier, always peeling off into a swarm of Zeros while calling out an enthusiastic "I've got 'em, Pappy!" over the radio. Ginty made no attempt to vindicate the television series; "I think everybody knew that the show was kind of unrealistic," he said. (Boyington was never called "Pappy" by his squadron, for example; that was an invention that came well after the war.) "It was really meant as a kids' show. It was not meant to show anything about war." The show lasted only two seasons, its demise due to a combination of economics and, Ginty suspects, influence on the network from those who may have felt the scripts did not do the original heroes justice. However naive the character of T.J. was, Ginty is no fool. He holds a deep regard for the original Black Sheep, perhaps because he has attended many events like this where he has heard the tales the Black Sheep tell.

An F4U-5's checkerboard cowl screams "I'm from Marine squadron VMF 312!" Dale Snodgrass tucks in behind Ray Dieckman (opposite).

At the Gathering of Corsairs and Legends dinner and symposium on Friday night, the eve of the airshow, the tables were filled mostly with those who hadn't been there during the reign of the Corsair. Those who had—the veteran pilots—were dispersed throughout the hall, one to a table, to share their stories. Each Legend took a few minutes at the microphone to reflect on his experiences from the distance of a half-century. The stories tended more toward the humorous than the heroic, and, unlike their film counterparts, these men express modesty mixed with an appreciation for how lucky they are to be here to talk about it all.

Glen Bower, who spent part of his second World War II tour with the Black Sheep, remembered the time he came out of a cloud one day: "I'm flying formation. With a Zero. I looked across...and he smiled back at me. There was no way I'm going to get on his tail. So I pulled back up into the cloud and left him for someone else."


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Tom Emrich was flying wing for Boyington during the latter days of a second tour with the Black Sheep. During a fighter sweep, Emrich spotted "a Zero on the most perfect beam shot you'd ever want to see. The machine guns were twinkling on the cowling and a stream of fire was going between me and Boyington." Emrich had to drive his Corsair through the machine gun fire in order to cut off the attack on Boyington. "They used the 7.7 [machine guns] to train their cannons, and when they had you in their sights, they fired their cannons." A 20-millimeter cannon shell exploded at the juncture of the vertical fin and the fuselage, severing Emrich's rudder cables. He nursed the fighter home and managed to get it on the ground in one piece.

Ed Harper was lucky to be sitting anywhere 55 years later. Harper had likely been hit with a .51-caliber armor-piercing anti-aircraft round, which collapsed one lung and nicked his spine, paralyzing his legs and leaving "a hole in his back where you could put your fist," according to John Bolt, another pilot on the raid. Slumping in and out of consciousness, Harper was guided home by his wingmen and only barely managed to land the stricken Corsair. William Heier struggled during his two minutes with the microphone to come to grips with something he couldn't quite bring himself to recount—perhaps an aspect of war more heinous than heroic. In closing, Heier found a path to vindication. "We could have done a lot worse," he said.

Allan McCartney, who flew his third combat tour with the Black Sheep, brought the mood of the symposium back full circle. "I've flown a lot of airplanes for the Marine Corps," he said. "I've brought four [Corsairs] back that were so badly shot up that [the maintenance crew] just pushed them off the side of the runway and used them for spare parts. I love the Corsair."

Affection for the airplane was late in coming when it entered the fleet to post a mixed record. Fast and rugged, it was also hard to land aboard carriers, and its accident rate caused the Navy to transfer it to the Marines, who flew the airplane from the beach. Later models fixed problems that had limited forward visibility over the long nose, and carrier landings became less of a challenge. A Navy History Office summary says its aerial combat record was 2,140 aircraft destroyed against 189 losses.

The Black Sheep said this will be their last reunion. In contrast, Jack Holden said his squadron, VMF-312, is a "very closely knit group. I think we will continue to have a reunion until the last man stands."

At the airshow the following day, retired Navy pilot Dale Snodgrass, call sign "Snort," flew the solo Corsair demonstration in the airshow, and his routine was mesmerizing. Snodgrass starts a long turning dive from 3,000 feet and ends up at about 25 feet above the ground, doing an airspeed of 320 knots—about 370 mph. "That airspeed gives the famous Corsair whistle," he says. The distinctive sound comes from air entering the oil cooler intakes mounted in the roots of the F4U's hallmark feature: inverted gull wings. The wings

Clockwise from below: Inverted gull wings reach halfway to the ground, and the short, stout gear covers the rest, leaving plenty of room for the huge prop. The presence of seven F4Us at the Indianapolis airshow was a magnet for warbird buffs. "Snort" Snodgrass was too young to fly in World War II, but he racked up victories with a grateful Indy audience. A chin airscoop identifies Jerry Beck's Corsair as an F4U-4.

were built that way so the main gear legs could be designed short and stout while providing the huge prop ground clearance.

In low passes back and forth across the airfield, Snodgrass trades airspeed for altitude and back again without inflicting high G loads, respecting the machine while pleasing the crowd. At the finish, there's a long, low, fast swooping pass for the cameras.

During the performance, Snodgrass is way too busy to think about the airplane's history. "But I tell you, when I walk around it…that's when it touches me," he says, his voice lower and softer. "My father flew Corsairs at the end of World War II. I just appreciate the privilege of being in an airplane like that." He also appreciates the generosity of owner Jim Read, who lets him "have the keys to such a precious piece of equipment."

Read flew Skyraiders in the Marines, then retired to civilian life as a banker. Success afforded him the option of returning to flying upon retirement. When he called warbird dealer Mark Clark to inquire about a P-51, he learned that a Corsair was for sale. He bought the airplane from renowned warbird collector Doug Arnold in England. It was shipped to the United States and flown to Indiana, where Read took his first flight in it.

"I assumed that the Corsair…would be more difficult to fly, and I was totally wrong," said Read. He particularly enjoys the Corsair's control authority and response at low airspeeds. "At 90 knots, you can just take the stick and go all around with it," he said, as if twirling an imaginary baseball bat in a big circle, "and it just kinda wallowed. I thought, *Wow, I can't believe this! It's so easy!*"

Easy to fly or not, owning the Corsair is a responsibility Read takes seriously. "I want to keep it flying and I want to keep it safe and I want to keep it in one piece," he says. When it's not flying, his F4U-5 is on loan to the Indiana Air Museum in Valparaiso.

Read's Corsair sported the paint scheme of Marine squadron VMF-312, perhaps the most distinctive one associated with F4Us: white checks alternating with traditional navy blue. First Lieutenant John J.E. Holden designed the color scheme in June 1943, and it has become the most enduring squadron motif in history. Both the squadron and the checkerboard pattern survive today.

Holden was in attendance, and his comments echoed those of every pilot lucky enough to fly a Corsair. "If anyone were to ask me to name the finest [American] fighter during World War II—unequivocally—the Corsair. I've never flown a P-51, and I'm sure some of those boys would give you some argument. But the Corsair could be a fierce fighter and a loyal companion at the same time, and the Corsair never, even under difficult circumstances—like flying with an oil pressure gauge that read zero—did it let me down."

Late in the day, as the airshow was winding down, the public was shooed from the row of parked Corsairs, and the pilots gathered for a quick briefing before mounting up. Soon, word came from ground operations director Arlene Samuelson, and one by one the ground crew signalled "Start engine." The massive propeller blades initially struggled to turn but soon spun into a blur, blowing a curl of smoke away from big blue cowlings, and the Corsairs taxied out in staggered order to match the planned takeoff sequence. One by one, they took off from the east end of the airport, tails floating up as they gained speed. They retracted the gear, gathered more speed even as they climbed, and entered their element. Then each one returned to beat up the airfield in a round-robin lazy trail formation.

There were five Corsairs flying together on that day, the most just about anyone could remember seeing at one time since Korea. Four of them finally formed up in a classic finger four, and, from stage left, made a pass over the runway. The announcer was silent, letting everyone appreciate the sight and the sound. Passing by in steady formation, they were soon lost in the sun. There was nothing to do, really, but try to memorize it all.

Illustrations by Ian Marshall

SEAFARERS

Aircraft that plied the world's waterways.

It is said that life began in the ocean, and so did commercial aviation. Aircraft that operated on water included two broad categories: flying boats, which lack wheels and can land only on water, and amphibians, which have wheels and can set down on either water or land. With more than 70 percent of Earth's surface covered by water, such aircraft had a huge advantage over land-dwellers.

In the 1930s, when postal service contracts first sent aircraft across oceans and continents, few substantial airports existed. But the aerial yachts of the day could operate from rivers, reservoirs, lakes, and oceans. Initially, passengers were boarded only if the weight of the mail allowed for extra cargo.

The United States' Pan American Airways and Great Britain's Imperial Airways pioneered the world's seaplane routes. Throughout the 1930s, Imperial flew from England to Europe, Africa, the Middle East, India, Asia, and on to Australia. (Imperial claimed the world's longest air route, some 13,000 miles from Croydon, England, to Brisbane, Australia.) Pan Am, having staked a claim on the Pacific in the mid-1930s, had also commanded the Caribbean, South America, and the north Atlantic by the end of the decade. France forged a link across the narrowest stretch of the south Atlantic, from Dakar, Senegal, to Natal, Brazil, in 1930, as did Deutsche Lufthansa from Berlin to Brazil in 1934 (and on to Buenos Aires via landplane). During World War II, most aircraft were pressed into military service, and at war's end, with landplanes having grown more capable and airfields sprouting around the world, the elegant seaplanes faded into obsolescence. The evocative images presented here are excerpted from renowned maritime artist Ian Marshall's latest book, *Flying Boats: The J-Class Yachts of Aviation* (Howell Press, 2002).

Right: Pan Am's Martin M-130 *China Clipper* at Wake Island, mid-Pacific, 1935. Pan Am built refueling bases and passenger accommodations on Midway, Wake, and Guam, the stepping-stone islands that allowed passage from San Francisco to Hawaii to the Philippines in five days. Martin built three M-130s, each of which usually carried 500 pounds of mail and up to eight passengers on this route. The 2,400-mile San Francisco-Honolulu segment took about 18 hours.

Left: Pan Am Sikorskys at Dinner Key, Miami, 1935. The eight-passenger Sikorsky S-38 amphibian (in the water) pioneered the airline's Caribbean and Central American routes. The S-40 (in front of the hangar at right) was a larger, 38-seat version of the S-38 that Pan Am used in Central and South America. The S-42 (aloft) was the showstopper, with a range of 1,200 miles, double that of the S-38. The 32-seat S-42 debuted on the Miami-Rio de Janeiro route in 1934.

A Short S-23 Empire departs from the Nile, downriver from Cairo, Egypt, on Imperial's British Empire Middle East routes to India, the Far East, and Australia, 1936. (The houseboat on the bank was a diversion for passengers.) Empires epitomized ocean liner luxury, with sleeping berths, leather seats, linen curtains, and fresh-cut flowers. The 17-passenger flying boat carried a crew of five, as well as 4,500 pounds of mail.

Boeing B-314 *Atlantic Clipper* moored in the Tagus River, Lisbon, 1940. The B-314 had twice the power of the Martin M-130 and could carry 74 passengers and a crew of 12 over a range of 3,500 miles. From Lisbon, B-314s on the southerly north Atlantic route flew west via the Azores and Bermuda to Baltimore or New York. The *Pacific Clipper*, stranded near Auckland, New Zealand, after the Japanese attacked Pearl Harbor, was forced to head west, negotiating 31,500 miles to arrive at the Marine Air Terminal in New York a month later.

Dornier Do J II *Wal* catapulted from the depot ship SS *Westfalen*; at right: Do 26, 1938. Deutsche Lufthansa used Dornier *Wal*s on its mail service across the south Atlantic. Because a greater payload could be catapulted from a ship than could take off from water, Heinkel-built catapults launched flying boats at sea to shuttle mail between Berlin and Buenos Aires. The sleek Do 26, with retractable wingtip floats, was built for nonstop north Atlantic crossings; it flew south Atlantic mail routes and was being prepped for passenger service when the war cut its career short.

Consolidated PBY, Diego Garcia island, Indian Ocean, 1939. The 4,000 PBYs built by Consolidated served as patrol bombers and search-and-rescue craft for the Allies during World War II. Named "Catalina" by the British, the PBY cruised at a mere 117 mph, and, with no armor or self-sealing fuel tanks, was vulnerable to anti-aircraft fire, but its 2,500-mile range and rugged construction made it indispensable (see "Going the Distance," Restoration, p.38). The PBY *Guba* (above), in private hands, made the first round-the-world flight at the equator. After the war a few PBYs flew passengers in Alaska, the Caribbean, and Australia, and for many years served as fire bombers for the U.S. Forest Service.


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AMPHIBIAN

How a Japanese sub hunter shed its combat gear to become the world's greatest open-ocean rescue craft.

Story and photographs by Tim Wright

On a cold day in January 1992, U.S. Air Force Captain John Dolan ejected from his damaged F-16 at 25,000 feet and landed in the Pacific Ocean about 700 miles from the Japanese mainland. For the next four hours Dolan lay in a tiny rubber life raft that was tossed and continually swamped by high seas; he eventually suffered severe hypothermia. Finally, when he was barely conscious, Dolan saw a large, four-engine aircraft—a ShinMaywa US-1A bearing the Rising Sun of the Japanese military—slowly circling his raft.

Aboard the US-1A, a radar at the copilot's station indicated that the waves below were just over nine feet high. US-1A Pilot Commander Hideki Kida put the 50-ton aircraft down in the churning ocean and taxied to within 50 yards of Dolan's raft. Two rescue swimmers got to Dolan and hauled him aboard the US-1A, and in another four hours Dolan was at the military hospital at Yokota Air Base, Japan.

With this rescue, one of 628 flown by a US-1A since it entered service in 1976, the aircraft completed for the first and only time the mission it was created to fulfill: rescuing military fliers. In its years of service, the US-1 type, with its 12-member crew, has made its real impact by saving civilians. To sailors at sea and people living on remote Japanese islands, it has been an aerial lifeline, an odd role for an aircraft that started out hunting submarines.

The US-1A began life as the ShinMaywa PS-1, an anti-submarine aircraft that first flew on October 5, 1967. A Japanese-designed and -built flying boat, the PS-1 tracked submarines with a dipping sonar—an acoustic device lowered into the ocean—and was armed with torpedoes, depth charges, and five-inch rockets. The massive underwater microphone was so large that crew members could barely squeeze past when it rested inside the aircraft.

On a typical anti-sub mission, the PS-1 crew would range over hundreds of square miles of ocean, landing 12 to 16 times. At each landing, the crew, like fishermen lowering a hook, would submerge the sonar, trying to catch the fleeting sounds of an enemy submarine.

ShinMaywa built 21 PS-1s, which served the Japanese Marine Self Defense Force until 1980, when Japan chose a different aircraft for anti-submarine missions. Lockheed's P-3C Orion was faster than the PS-1, had a longer range, and deployed a series of floating sonar-emitting buoys that could weave a tighter web around a submarine. It was also easier to maintain and more comfortable for its aircrew. It wasn't long before the PS-1 was looking for a new mission and found one in the most unlikely place: the P-3C Orion.

With its 2,700-mile range, the P-3C ventured into stretches of the Pacific far from the home islands, and it seemed prudent to the Japanese defense force to have a rescue craft available in case an aircraft was lost in an area outside customary shipping routes. So the PS-1 shed its sonar, rockets, and torpedoes and was reborn as the US-1 rescue air-

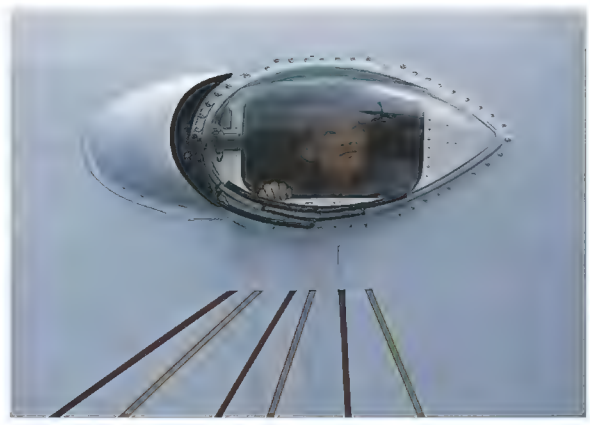
ShinMaywa's US-1A, cleansed of the corrosive sea after every mission (opposite), continues an ancestral line of flying boats, starting with the wartime H6K "Mavis" (above).

KAZUYA OKUMURA/SHINMAYWA INDUSTRIES, LTD

IN THE YEARS AFTER WORLD WAR II, MOST COUNTRIES ABANDONED THE CONCEPT OF LARGE FLYING BOATS AS PATROL CRAFT, BUT SHINMAYWA'S HISTORY KEPT IT FOCUSED ON THE TYPE.

craft. Its primary mission: to rescue P-3C aircrews. In the process of rebirth, the new US-1 evolved from a true flying boat into an amphibian. ShinMaywa engineers replaced the flying boat's beaching gear, with which it could roll onto a prepared shore under its own power, with sturdy landing gear, which could support a 50-ton aircraft landing on a runway at about 75 mph.

In the years after World War II, most countries abandoned the concept of large flying boats as patrol craft, but ShinMaywa's history kept it focused on the type. The company traces its beginnings to 1918, when it was known as Kawanishi. It developed a line of floatplanes and flying boats that helped tie the Japanese empire together in the years leading up to World War II. By the end of the war, Kawanishi had built 2,862 aircraft. The most famous were a single-engine fighter known by the Allies as the "George" and two four-engine flying boats, the H6K "Mavis" and H8K-2 "Emily." The Emily had a 124-foot wingspan (nine feet longer than that of the British Short Sunderland and 21 feet longer than a Boeing



Top: With flaps deflected for added lift, a US-1A climbs from the coastal waters near Kobe, Japan. Aircrew enter the craft through a hatch from which rescue rafts are also launched. An observation bubble (below) augments search sensors.

B-17's), and, with a range of 4,500 miles, it has won accolades from aviation historians as the most advanced flying boat of the war.

The U.S. Navy was impressed enough with the Emily to have transported one after the war for testing at its Patuxent River facility in Maryland. Surface tests were conducted in the Chesapeake Bay, but engine failures brought the testing to a premature close, and the aircraft

was exiled to the Norfolk Naval Air Station in Virginia, where it was wrapped in plastic and relegated to the station's lost and forlorn. By then, it was the last known Emily in the world. In 1980 the Navy, at the request of the Japanese government, returned the orphaned Emily to Japan. It recently underwent a major restoration and is on display at the Museum of Maritime Science on Tokyo's waterfront.

During the war the Kawanishi factory in Kobe, a coastal city about 20 miles southwest of Kyoto, built 167 Emily flying boats before the U.S. Army Air Forces added the factory to the strike list of B-29s raiding Japan. At one time, the factory was the largest enclosed structure in Asia. By war's end, it was a twisted ruin. Today, as ShinMaywa workers climb over a US-1A brought in for overhaul, sunlight streams through bullet holes left in the factory walls.

For Kawanishi, the postwar years were difficult ones. While Japan was under U.S. occupation, the company was forbidden to build aircraft. Its workers transferred their skills in aluminum and metal working to making pots and pans, and later the company expanded into building and maintaining trucks. Before long, the massive hangars where the Emily had been assembled were rebuilt and filled with hundreds of trucks in various stages of construction or repair. Kawanishi changed its name to ShinMaywa to escape some of the notoriety that stemmed from its World War II operations.

At the outbreak of the Korean War, ShinMaywa was invited back into the aircraft business as a maintenance depot for U.S. military transports. The company had retained its expertise in flying boat construction and seized the opportunity to continue working with the technologies it had developed during World War II. Among its areas of interest was short-takeoff-and-landing (STOL) technology for marine aircraft.

With the help of the U.S. Navy, ShinMaywa acquired a Grumman UF-1 Albatross, an amphibious search-and-rescue aircraft with a 2,850-mile range that served not only the Navy but the U.S. Air Force and Coast Guard as well. The Albatross could accommodate a crew of six and was powered by two 1,425-horsepower Wright R-1820 engines. To create a STOL aircraft, ShinMaywa added two 600-hp Pratt & Whitney R-1340 engines, stretched the nose, and refitted the aircraft with a high T-tail. The modified Albatross was named the UF-XS and became a research platform for investigating STOL technologies.

The limiting factor in open-ocean operations is the impact stress created by waves slamming against the hull during takeoff and landing; reducing takeoff and landing speeds reduces the stress on the aircraft. ShinMaywa experimented with an array of high-lift devices to enable the UF-XS to take off and land at slower speeds. The tailplane and outer sections of the wings had leading edge slats. Flaps on the inner sections of the wings' trailing edges could be deflected as much as 80 degrees, and on the outer sections, as much as 60 degrees. Engineers augmented these movable surfaces with an experimental system for controlling the boundary layer.

The boundary layer is a thin layer of air molecules near the surface of an aircraft (or any object moving through the air) that, because of the air's viscosity, moves at a different velocity from the air farther from the surface. In fact there are a number of "layers" in the boundary layer, all flowing at slightly different velocities.

As an aircraft approaches the low speeds associated with landing, the boundary layer flowing over the wing becomes increasingly turbulent and the wing loses lift. To retain smooth flow, and therefore lift, as long as possible at slower speeds, ShinMaywa devised a system to blow air over the flaps and the elevator to keep the airflow smooth, enabling the aircraft to

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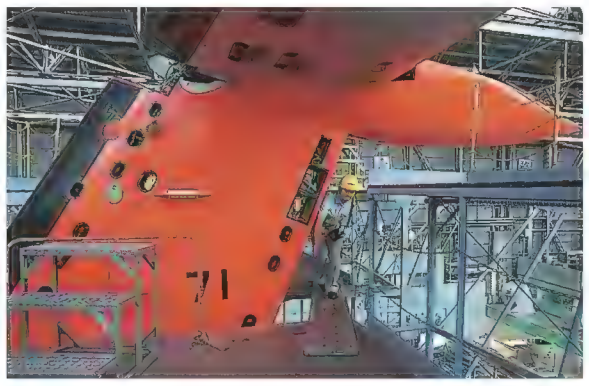
Kawanishi produced 167 H8K Emily flying boats (left) during World War II at the factory in Kobe, where today ShinMaywa's 19th US-1A is under construction (below). With four 14-cylinder radials and a 124-foot wingspan, the H8K could patrol over 3,000 miles of ocean.

maintain lift and control at low speed. The air was produced by a 1,250-hp General Electric T58 turboshaft engine mounted in the aircraft cabin.

The UF-XS research showed that aircraft with such a system for boundary layer control (BLC)—as well as improved hull designs—could operate in much rougher seas than had been possible before. ShinMaywa incorporated the high-lift devices developed for the research program into the design of the anti-submarine PS-1 and the US-1/US-1A rescue aircraft.



The company built 23 PS-1 anti-submarine aircraft and 18 US-1/US-1A search-and-rescue aircraft. Although their BLC systems are unique, the amphibians inherited their configurations in part from their noted ancestor, the Kawanishi H8K-2 Emily. Their four General Electric T64 turboprop engines, license-built by Ishikawajima and each rated at 3,493-hp, are suspended from a wing set high on the fuselage. Seaplane designers place the engines as high off the water as possible to keep the air intakes from ingesting water. Also, saltwater is abrasive and corrodes propellers as well as the numerous rotating blades inside turbine engines. Besides mounting the engines high, ShinMaywa designers added a spray-suppressing chine around the forward hull.

All PS-1 and US-1 aircraft have been retired, but seven US-1As remain in service, and the type is still in production. As US-1A number 19 neared completion at the Kobe factory last year, the next generation of rescue am-

TODAY, AS SHINMAYWA WORKERS CLIMB OVER A US-1A BROUGHT IN FOR OVERHAUL, SUNLIGHT STREAMS THROUGH BULLET HOLES LEFT IN THE FACTORY WALLS FROM THE WAR.

The US-1A's complex 109-foot wing, with leading edge slats and high-lift flaps, supports four turboprop engines. Top: A ShinMaywa worker squeezes past the tail section of airframe no. 19.

phibian was emerging right beside it.

The US-1A "Kai" is based on the 1960s technology of its predecessors and therefore has the same capabilities for STOL and rough-sea takeoffs and landings. But the Kai (Japanese for "modification") also incorporates a pressurized hull that will allow the aircraft to fly at 30,000 feet instead of its current 10,000. At higher altitudes, the Kai will have greater range and will avoid the weather that limited US-1A operations. The Kai will also include modern satellite navigation and communication systems. The flight deck features a head-up display and night vision technology and resembles the glass cockpits of contemporary airliners. The first airframe was completed last month, and a rollout is scheduled for March 2003.

ShinMaywa managers believe the improvements will help the new amphibian compete for world sales, and they hope to market it not only as a search-and-rescue craft but also as an air tanker for fighting forest fires or a patrol aircraft for maritime research. "We think the Kai is the only aircraft capable of open ocean landing," says ShinMaywa engineer Katsuhito Akashi. "There are other amphibious aircraft available, but none of them are capable of landing in those conditions." Akashi points out that to investigate an ocean oil spill, a ship might need as much as a week to travel to the spill site and back. The Kai could make that round trip in a single day.

The Kai's only competitors for such markets are amphibians produced by the Russian company Beriev, known for a long series of marine aircraft dating back to the 1930s (see "When Ships Have Wings," Dec. 1995/Jan. 1996). Beriev, located in Taganrog near the border of Russia and Ukraine, received certification last year for its twin jet Be-200 and earlier this year for the smaller piston-engine Be-103. The company has built ten Be-103s, six of them for Russia's forestry service.

The big Beriev, powered by two Motor-Sich D-436TP turbofan engines, each producing 1,650 pounds of thrust, can cruise at over 400 mph, but it is more expensive to operate than the Kai and can land only in seas with waves no higher than four feet. With the latter limitation, the Beriev is useful for lake and river landings but is not as capable as the Kai for ocean search and rescue. Beriev is marketing a transport version of the Be-200, which could seat as many as 70 passengers, and hopes to begin building as many as seven Be-200s each year.

If the Kai is to compete head to head with the Beriev, ShinMaywa will need export approval from the Japanese government. The Japanese constitution, written largely at the direction of the United States and its allies after World War II, prohibits any Japanese product capable of offensive military action from being sold to another country. Since the US-1 and US-1A began their lives as anti-submarine aircraft, ShinMaywa cannot sell them overseas.

The main differences between the Kai and the US-1A are the Kai's fly-by-wire controls and its pressurized hull, but these are significant enough, ShinMaywa managers hope, to earn a new designation that will enable the company to pursue overseas sales.

The Kai's first stop, however, will be Japan Maritime Self Defense Force Base Iwakuni, on the southern tip of the big island, Honshu. The former headquarters of Admiral Isoroku Yamamoto and a former fighter base for the Japanese Imperial Navy, Iwakuni now hosts U.S. Marines flying F/A-18s. It is also home to Air Rescue Squadron 71, and when the first Kais complete flight testing, they will be based at Iwakuni with the seven US-1As that are still in service. It was a Squadron 71 crew that rescued Captain John Dolan in 1992.

Captain Dolan is now Major Dolan, an F-16 flight instructor in the Air Force Weapons School at Nellis Air Force Base in Nevada. Of his 1992 rescue, he says: "From ejection to rescue was a whole series of miracles." No other aircraft in the world inventory could have gotten to him in time in the sea conditions he was experiencing. "Six hundred and eighty nautical miles from shore," he remembers, "nine- to 12-foot seas, 25-knot surface winds, and I am here to tell the story!"

Flying boats and amphibians have all but disappeared, but, as Dolan will tell you, there's at least one good reason to keep the old—and new—hull landers around.

KAZUYA OKUMURA/SHINMAYWA INDUSTRIES, LTD

Rescue Flight Squadron 71, stationed at the Iwakuni Air Base, operates seven US-1A amphibians and practices search-and-rescue missions in Japan's Inland Sea (above). Before each exercise, ground crew make certain the engine intakes are clear (right). The US-1A's black clown nose carries a Litton search radar.

Chalk's ocean airways

In south Florida, air travel is wet and wild.

by HENRY SCAMMELL | PHOTOGRAPHS *by* CAROLINE SHEEN

Now departing Paradise… All day long, Chalk's amphibious Grumman Mallards shuttle tourists in and out of Paradise Island and other Bahamian destinations.

Chalk's is a modest operation, from its plain little aircraft cabins (above right) to its minimalist terminals (right: Bimini). Above, a 1930s float-equipped Fairchild 71 is small enough to be towed through the street by car. For a short period in the 1990s, Pan Am Air Bridge owned the airline and flew its Mallards with "Air Bridge" livery (below).

Arthur Burns Chalk's career in seaplane flying began in the unlikely setting of Paducah, Kentucky. In 1911, Chalk, 23, was working there as a mechanic when a barnstormer and seaplane flier named Tony Janus came to town. Janus' aircraft had developed engine trouble. He and Chalk struck an agreement: Chalk would fix the engine; in return, Janus would teach the young man how to fly.

COURTESY CHALK'S OCEAN AIRWAYS

A few years later, Janus migrated to Miami and, operating a Benoist flying boat, started the nation's first scheduled passenger air service, the St. Petersburg-Tampa Airboat. Chalk must have been inspired by Janus' example; he moved south as well. Initially making a living as a barnstormer, in 1917 he founded the Red Arrow Flying Service,

on the dock of the Royal Palm Hotel in Miami. His office was a small table under a beach umbrella, and his reservation system was a single crank telephone hanging from a pole. Because neither Miami nor the Bahamian islands he frequently flew to had airports, Chalk equipped his three-seat Stinson Voyager with floats so that he could take off and land the aircraft on water.

In 1919, the operation, by then named Chalk's Flying Service, inaugurated a regular schedule to Bimini, a Bahamian island 50 miles off the southern Florida coast.

Eighty-three years later, the business, now called Chalk's Ocean Airways, is still flying passengers in seaplanes back and forth between Florida and the Bahamas. It is, according to no less an authority than the *Guinness Book of Records*, the world's oldest continuously operating airline.

THE MIAMI HERALD

Right: "Pappy" Chalk, c. 1959. Below: Captain Rebecca Diamond.

August 2002. At the airport in Fort Lauderdale, Chalk's passengers start their trips downstairs, at a tiny, dimly lit ticket counter. Long lines are a rarity. All baggage is checked through to the hold; almost no carry-on is permitted. On a recent trip, the only visible exceptions were cameras, purses, a tape recorder, and a lined writing tablet, and the last two probably apply only if you are doing a story on the airline.

Then it's on to a cinderblock waiting room. It's not uncommon for the room to hold two flights' worth of passengers at once, but even at capacity, the crowd wouldn't fill the last nine rows of a 737.

The mix of passengers depends on the destinations: groups of fishermen and some couples headed to Walker's Cay and Bimini; more couples, families, and a number of business people headed to Atlantis, the resort complex on Paradise Island. Everywhere are printed T's and bleached jeans and cutoffs.

Bimini, a ragged seven-mile strip of sand, was, in the early part of the century, principally a destination for sports fishermen. That changed abruptly in 1919, with the enactment of Prohibition. Because it was the nearest of the still-wet Bahamas, the island became a hub for smuggling alcohol into the States. Chalk's began catering to bootleggers traveling to Bimini to contact suppliers, pay them, and check on their inventory; with equal courtesy and reliability, it transported numerous federal agents shadowing the smugglers. Many of the most prominent gangsters of the era used Chalk's, including a stocky, moonfaced Sicilian named Al Capone.

Chalk's transports employees to and from the Atlantis resort-casino complex on Paradise. Opposite, above: In Miami's Biscayne Bay, Mallards take off next to cruise ships. Below: A flock of Grumman Gooses, which Chalk's flew before acquiring Mallards.

With ascending fortunes, Chalk built himself a small kiosk-style terminal at Watson Island, situated in Biscayne Bay between Miami and Miami Beach. He also upgraded his inventory. One early acquisition was a Benoist biplane. Unlike the float-modified Stinson, the Benoist was a flying boat—a hull lander, with no floats. The engine, built by Roberts Motors, was a two-stroke, water-cooled model that had the frequent bad habits of backfiring and belching flames, challenging Chalk's skills equally as a mechanic and as a pilot.

When Prohibition ended in 1933, Bimini and the airline that served it began to attract another tier of travelers: Errol Flynn was a Chalk's aficionado, and later so were Ava Gardner, Lana Turner, Judy Garland, and the eventual all-time king of flying boats, Howard "Spruce Goose" Hughes. Ernest Hemingway loved Bimini for its access to deep-water fishing, and was a regular Chalk's passenger during the 1940s.

In later years, the little airline moved up to the Sikorsky S-38, a far more reliable multi-engine flying boat. Rival Pan American Airways used S-38s to survey the Caribbean and serve island destinations there. Chalk also flew a single-engine Fairchild 71 that had been outfitted with floats.

After World War II, he upgraded to Grumman amphibians: a five-passenger Widgeon, a nine-passenger Goose, and, in the 1960s, the first of several Mallards. Unlike its smaller predecessors, the Mallard had tricycle landing gear, a stressed-skin, two-step hull, and wing-mounted floats for stabilizing the craft on the water (these could also serve as auxiliary fuel tanks).

In 1966, Chalk, by then known as Pappy because of his white hair, stopped flying, having logged around 17,000 hours. Four years later, he sold the business to Dean Franklin, who had been a pilot for the small airline for 30 years. By then, Chalk's was operating four Gooses and three Mallards, and the staff had grown to 16, including pilots and maintenance and sales personnel.

Even after retirement, Chalk could not leave the love of his life. "He came by every day except Sundays to feed the birds, and to feed us," recalls Jean Munroe, Chalk's system and interline manager. "He brought seed for the pigeons, and soup and sandwiches from a diner in Miami for the employees. He didn't even have a driver's license; his niece brought him over, waited while he went through his daily routine, then drove him home."

In 1977, just short of his 90th birthday, the aviation pioneer who had never lost a passenger finally himself fell victim to gravity, slipping from a ladder while pruning a tree in his yard. He died soon after.

BIMINI MUSEUM

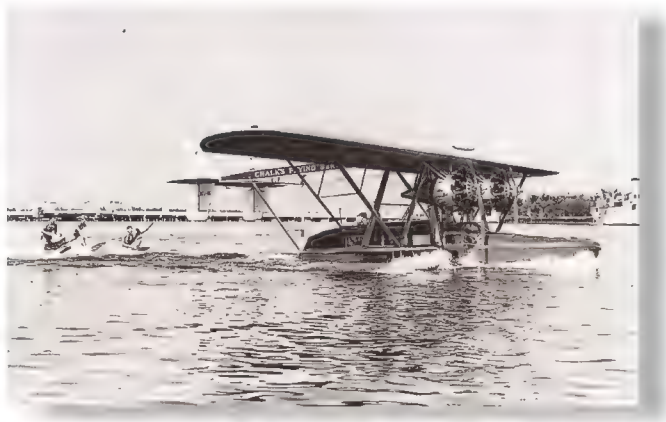
Since September 11, security restrictions have forced Chalk's to revise its Bahama-bound flights. The Mallards have for the most part been departing as landplanes from the Fort Lauderdale airport, rather than as seaplanes from Watson Island, which is considered more vulnerable to terrorist attack.

To a passenger standing at its threshold, the Mallard seems more like an airplane than a boat. But

Repair and maintenance go on around the clock. At midnight, workers ready a Mallard for operation the next morning. Below: The airline put a Sikorsky S-38 to a new use: towing water skiers at a Chalk's company picnic.

when one steps into the craft, that step is down. So is the next one. Compared with the design of similar-sized landplanes, the door of the Mallard is set higher in the hull to keep out the water, and both the captain and the first officer sit at a higher level in order to see over the bow. With those first steps, plus the scent of salt air, the airplane's second nature becomes apparent.

The Mallard's interior reflects the middle years of powered flight—the cabin walls are painted, rather than covered with fabric, and you can count the rivet heads—but the seats are comfortable. Seating is catch as catch can. There's no door to the cockpit, just an archway in the bulkhead, so you can look up at the pilot and first officer.



HISTORICAL MUSEUM OF SOUTHERN FLORIDA

Dean Franklin held onto the airline for slightly over a year, and in 1974 his successor sold it to Resorts International, which then operated a vacation complex on Paradise Island. Resorts CEO James Crosby had Grumman adapt the Albatross, a World War II search-and-rescue craft, for commuter usage. The result, the G-111, could carry 28 passengers. It entered service with Chalk's in 1982.

Following Crosby's death in 1986, Chalk's was owned briefly by his sisters and then successively by Donald Trump and Merv Griffin. In an attempt to save money, Trump cut the seaplane fleet to four Mallards and put the Albatrosses into storage.

In 1991, title passed to Seth Atwood, the heir to an auto parts fortune. Atwood approached his proprietorship as both a businessman and the conservator of a valuable public trust. Ironically, it was during his tenure that the airline experienced its first real tragedy. In 1994, two pilots were hurriedly ferrying an otherwise-empty airplane from Key West, and skipping the checklist, they failed to detect a hull leak that had apparently developed since the previous landing. During takeoff, water that had accumulated in the hull sloshed to the tail, shifting the center of gravity and causing the airplane to fall into the sea. Both crew members aboard died.

Under subsequent owners, Chalk's joined the resurrected remains of its one-time rival to operate briefly as Pan Am Air Bridge. That company, in turn, was sucked into the bankruptcy of another owner. Still, Chalk's kept flying.

At Miami and the Bahamian islands, the takeoffs are amphibious. Once the passengers have boarded, the Mallard sets off noisily, purposefully, on its landing gear, proceeding down a ramp and toward the water. At the

ramp's lip, the Mallard's nose dips and the tail bobs like a duck's. Once the craft is afloat, its roar is punctuated by two soft thumps as the landing gear, looking like the legs of a knock-kneed seabird, retract, folding up and nesting in wells in the hull. Spray flies by the window as the Mallard gathers speed.

Takeoff from water is very different from a runway takeoff. A flying boat is bound to the water's surface by the entire length of its hull, and passengers are aware of a greater sense of heavy lifting as the airplane labors upward to break that broad embrace.

The 60-mile trip to Bimini is usually flown at 1,000 to 2,500 feet, depending on the weather. At a cruise speed of 185 mph, it lasts only about 20 minutes from climbout to the start of descent. The island Walker's Cay is a few minutes further, and the trip to Paradise Island is three or four times higher and longer. Most Chalk's flights are smooth, and the views, especially on approach, are breathtaking.

As the Mallard flies low over the Bahamas, the shadows of fleecy clouds drift by like ragged, sunken islands. The color of the water ranges from wet canvas on the bonefish flats to bleached emerald on the shoals to deep cobalt at Tongue of the Ocean. (No wonder Al Capone, in the black-and-white poverty of the Depression, kept coming back for more.)

Family resemblance? A yacht and a Mallard pass companionably in the waters off Paradise. Below: Welcome to Bimini. The Mallards land near the island's main road.

During amphibious takeoffs, the Mallard's landing gear folds up and in (left). After flights, cleaning crews tip Mallards up to drain saltwater.

Longtime Chalk's manager Bill Jones left the airline briefly in a policy dispute with the successor to the bankrupt Pan Am owner, but he was brought back in the spring of 1999 by the court-appointed trustee just three days before the airline's operating insurance was to expire. He quickly found interim financing, averting a breach in service that would have ended Chalk's claim as the world's oldest continuously operating airline. In similarly rapid succession, Jim Confalone, an entrepreneur and former Eastern Airlines pilot, obtained the titles to five Mallards, which had fallen into the hands of various Chalk's creditors. Today, Jones is general manager, in charge of day-to-day operations, while Confalone is responsible for setting Chalk's goals and for developing its strategic partnerships.

Confalone also oversees inventory, and he has acquired a treasure trove of airplane parts and blueprints from Dean Franklin Aviation, the company founded by Pappy Chalk's successor. The old and brittle factory drawings for the Grumman amphibians have been carefully reproduced as computer files. During the 1946–1951 production run, Grumman built only 59 Mallards, so many vital parts no longer exist. The drawings

enable Chalk's machine shop to fabricate replacements.

"We do a lot to keep these airplanes aloft," says Jones. "One sixth of the airplane is minutely inspected for corrosion, cracking, or any sign of wear every 250 flight hours. That takes us through the whole airplane in 12 or 13 months. The landing gear are subject to a lot of stress and are inspected in every cycle. The airplanes are continually rebuilt, and there is very little left of the original."

The one serious anachronism is the model of engine now used. The original radials, two 600-horsepower Pratt & Whitney R-1340-S3H1 Wasps, were raucous, thirsty shakers, as hard on the ears as on the bones. Resorts International's James Crosby replaced them with turbine engines. The Pratt & Whitney Canada PT6 turboprops were fitted with propellers that are smaller than the Wasps'; because they have less contact with the water, they produce less spray and therefore less turbine corrosion. The conversions raised fuel efficiency by 20 percent, almost doubled the Mallards' range, and enabled Chalk's to increase each craft's capacity to 17 passengers.

BIMINI MUSEUM

At the moment, 14 pilots take turns flying the three Grumman Mallards, with each pilot logging 100 hours a month from Florida to Walker's Cay, Bimini, and Paradise Island.

One of the newer pilots is Rebecca Diamond. In the spring of 2000, Diamond, then a 24-year-old with a commercial pilot's license, was driving through Miami when she caught sight of a small float-equipped airplane overhead. Enchanted, she followed it to its landing on Biscayne Bay, and watched it taxi to a ramp on Watson Island. Nearby was a small, low building with a "Chalk's Ocean Airways" sign. She walked into the operations office and right then and there asked for an employment application.

tides and the wind and the boats and the jet skis. It's hands-on, no autopilot, with hop-skip-and-jump, 20-minute turns, and all-day-long days. But then they give you a lot of days off. It's a wonderful job." Last March, Diamond was made captain, the youngest in the fleet.

In addition to its regular service, Chalk's also runs a charter business; over the years it has carried British royalty, business titans, and miscellaneous rock stars to various private Bahamian islands.

Confalone says he has plans for an expansive future, though he keeps them confidential. He does acknowledge that he's had conversations with former owner Seth Atwood about bringing back the 14 warehoused Albatrosses.

Chalk's is resuscitating a fourth Mallard to fill out its fleet. Stay tuned: The airline's Albatrosses may migrate back to Florida.

Most passengers would find nothing particularly novel about a water approach to landing; those who regularly fly into Boston's Logan Airport, for example, are used to looking down and seeing whitecaps until the moment of touchdown. A water landing, on the other hand, is a different matter. The view out the window, once sky, is replaced not by a firm and friendly concrete runway but by a watery pathway among yachts and islets.

Landplane passengers used to a certain amount of bounce on touchdown might expect the seaplane to come in like a skipping rock. In fact, the opposite is the norm: The Mallard is in smooth, continuous contact with the sea from the first touch. When the drag of the water becomes greater than the lift of the wing, the view from the side windows is engulfed in a wall of spray, but only for an instant; then the airplane settles into its role as yacht, and the water skims by under the hull's aluminum skin as smoothly as an electric sander.

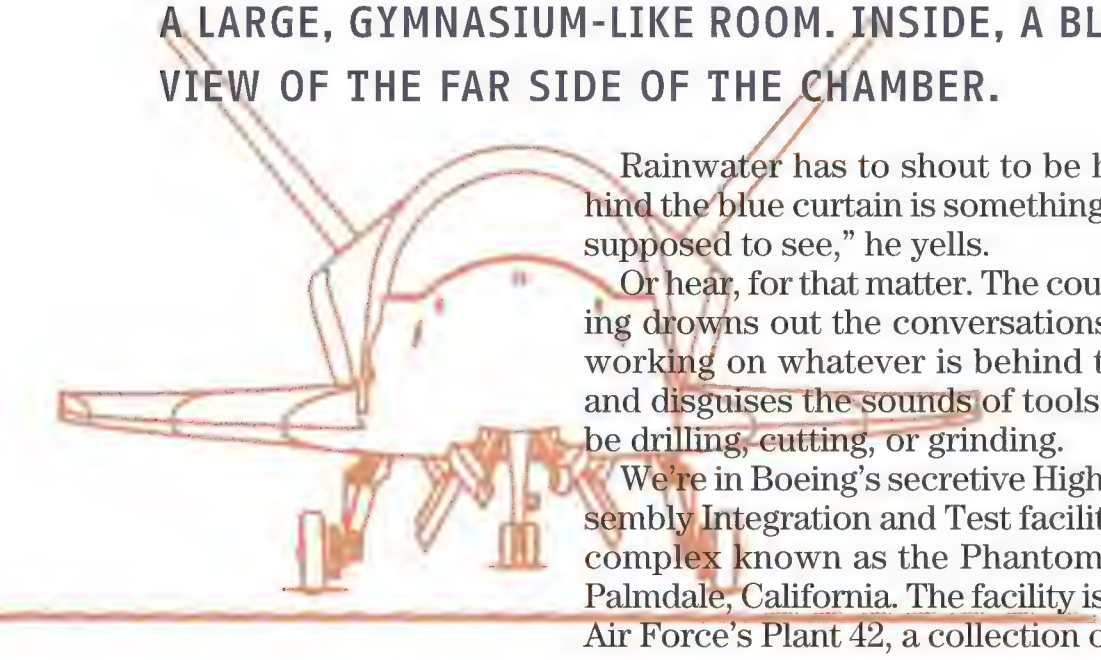
A few moments later, the seaplane makes its final change. It pauses at the water's edge, gathering its power with a roar and curtsy before lowering its landing gear and then rumbling up a ramp and onto land.

A Mallard leaves Bimini. Below: The Miami terminal still has a wall of coral from an early Chalk's kiosk.

Though Diamond had multi-engine certification, she was afraid she would be at a disadvantage because she had never flown an airplane off the water. But the airline called her back, and she started flying as a first officer that June. "Chalk's likes people who don't have a lot of sea time," she says. "Because it's such an unusual airplane, they like to train you specifically, so you don't come in with prior notions.

"It's the closest thing you can get commercially to World War II flying—much more strenuous than most pilot jobs because of the change of the

COUNTRY MUSIC SUDDENLY BLARES FROM UNSEEN LOUDSPEAKERS AS VETERAN BOEING MANAGER DENNIS RAINWATER OPENS THE DOOR TO A LARGE, GYMNASIUM-LIKE ROOM. INSIDE, A BLUE CURTAIN BLOCKS THE VIEW OF THE FAR SIDE OF THE CHAMBER.



Rainwater has to shout to be heard. "Behind the blue curtain is something you're not supposed to see," he yells.

Or hear, for that matter. The country crooning drowns out the conversations of people working on whatever is behind the curtain and disguises the sounds of tools that might be drilling, cutting, or grinding.

We're in Boeing's secretive High Desert Assembly Integration and Test facility, part of a complex known as the Phantom Works, in Palmdale, California. The facility is part of the Air Force's Plant 42, a collection of buildings where, historically, aerospace companies have worked on the projects that have made the United States the world leader in military and space technology. F-117 stealth fighters, B-2 stealth bombers, and space shuttle orbiters all sprang from Plant 42. Today, another technological push is taking place here. Lying on the unclassified side of this particular high bay is the partially assembled lower fuselage of a 28-foot-long experimental craft called the X-37. It is a technology demonstrator for a spacecraft that, launched on an expendable rocket, could eventually fly almost any of the missions of the bombers and orbiters that preceded it. At long last the Air Force would have the spaceplane it has pursued since the late 1950s.

Origin of the Species

It was named the Aerospaceplane when the 1950s designs first appeared. In the '60s, it became the X-20 Dyna-Soar. Secretary of Defense Robert McNamara canceled Dyna-Soar in 1963, before it ever flew, but the dream of a spaceplane survived through the next three decades in a series of studies and programs. The most ambitious was the National Aerospace Plane, a 1980s effort nicknamed the Orient Express (for its farfetched goal of carrying passengers from New York to Tokyo in two hours), but the technological leap it required overwhelmed the Air Force-NASA partnership formed to build it. The program dissipated into small technology development projects before being canceled altogether in 1992.

The direct antecedent of the Reusable Spaceplane was born in the early 1990s at the Air Force Research Laboratory at Kirtland Air Force Base in New Mexico. The program was called the Military Space Plane. Its advocates envisioned a craft that could do in space what an unmanned Predator reconnaissance aircraft and an E-3 Sentry Airborne Warning and Control System do in the air. In a crisis, the Pentagon would launch spacecraft called Space Maneuver Vehicles to return images of enemy positions, eavesdrop, coordinate air forces, and jam satellites. To accomplish such missions, the Space Maneuver Vehicles would do what previous spacecraft have not been able to: change orbital planes and altitudes.

After a mission, each SMV would blaze back into the atmosphere toward a runway, where Air Force ground crews would scramble to refurbish it in hours or days in what Air Force planners call "aircraft-like operations." Space Maneuver Vehicles would be unpiloted, and, best of all, they would operate safely above surface-to-air missiles.

The Air Force Research Laboratory took an important step toward developing its spaceplane in 1996, when it hired Boeing to build the X-40, a 22-foot-long flight test vehicle. Made of a graphite/epoxy shell with an internal aluminum frame, the X-40 was to test the aerodynamic handling characteristics of a returning spacecraft and to prove that a small vehicle designed for reuse could land autonomously on a 10,000-foot runway. In 1998, Boeing dropped the unpiloted vehicle from a Black Hawk helicopter; it dove toward Holloman Air Force Base in New Mexico from an altitude of 9,000 feet and used its autonomous guidance, navigation, and control system to land successfully. Later, the Army Aviation Technical Test Center supplied Boeing with a CH-47 Chinook helicopter and pilots to conduct a series of seven test flights for NASA. The X-40, dropped from 15,000 feet, landed on Runway 22 at Edwards Air Force Base in California.

"We were not off on the lakebed; we were coming in with all the other airplanes," says Randy Hein, Boeing's X-40 program manager. "They cleared the airspace, but we were coming in on an operational runway, which was a neat thing to be able to do." As Hein

Though the X-37 orbits only in artist renderings, it tests 40 technologies that any orbiting, reusable spacecraft will need.

BY BEN IANNOTTA

X-37 ART: BOEING; PHOTO COLLAGES: TED LOPEZ

WILL THE AIR FORCE FINALLY GET A SPACEPLANE?

IF IT CAN RISE ABOVE COMMITTEE REPORTS AND BUDGET BATTLES, BOEING'S X-37 COULD BE THE ANSWER TO AN AIR FORCE PRAYER

The daunting problem facing designers of reusable spacecraft is inventing a configuration that can achieve control through a full range of flight regimes.

speaks, the gleaming X-40 waits inside a storage facility at Boeing, like a Ferrari ready to be taken for another spin.

Hein and his team sweated out one moment during the first flight test at Holloman that captures the challenge of designing an aircraft to land without a pilot. "We had one touchdown where we lifted up and came back down—bounced, if you will," Hein says. The vehicle was undamaged, and the team's analysis quickly pinpointed the problem. When the X-40's tires touch down on the runway, the main gear tires spin up from zero to about 195 mph, creating a force that pushes the nose down. Piloted aircraft show the same nose-down tendency, and in training pilots learn how to compensate to keep the nose up on landing. In the X-40, flight software must compensate, and on the first landing, the X-40's automated control surfaces overcompensated (as more than one pilot has done), and the vehicle briefly lifted off. Boeing's engineers revised their computer model of the forces created by the tires' spin up and reprogrammed the flight software to increase the reaction rate of the control surfaces.

All subsequent landings were "nominal," as engineers like to say, and the improved computer model will contribute to smooth landings for the more complex X-37.

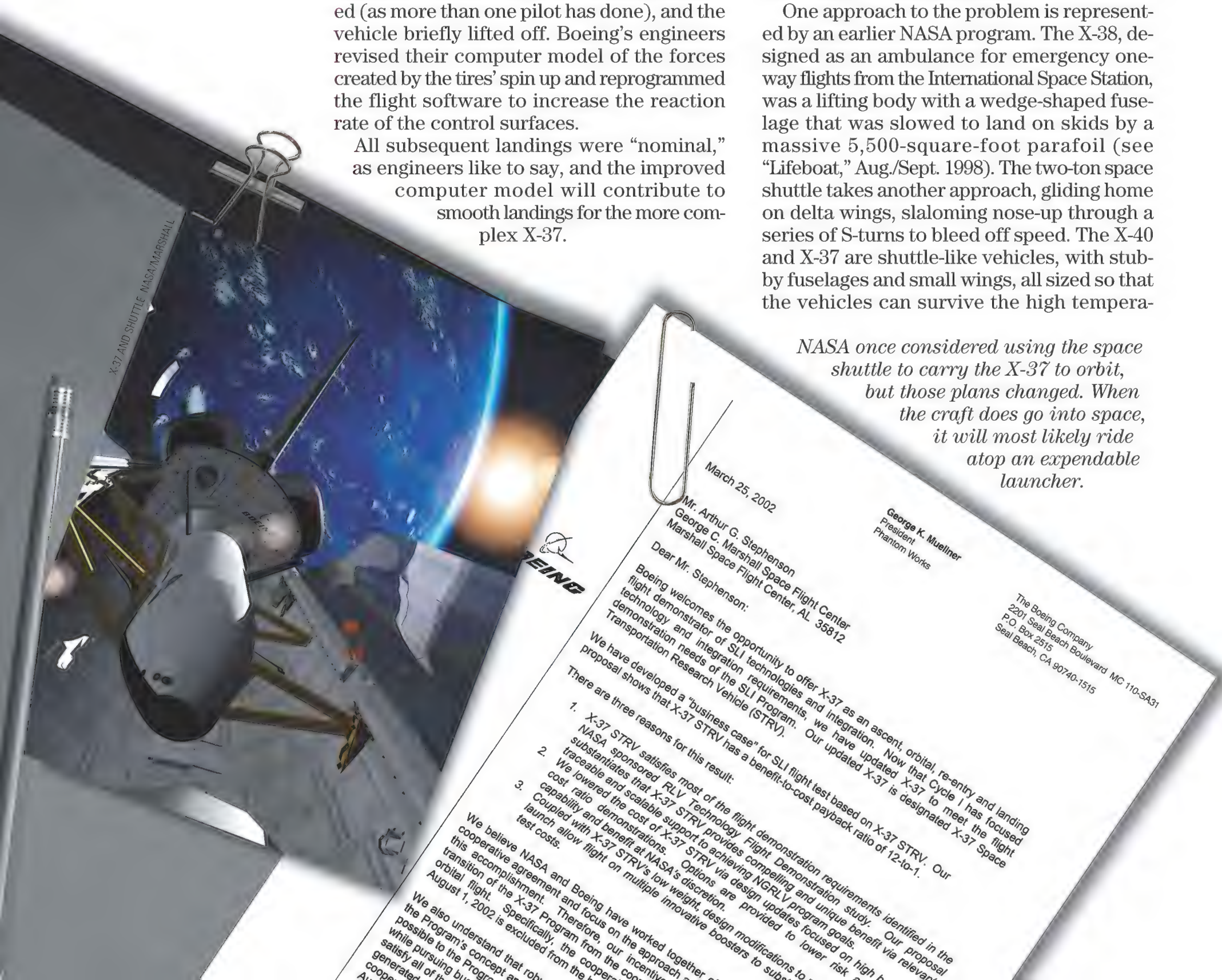
The X-37 is managed through a NASA program to test technologies in the propulsion, avionics, structures, and thermal protection systems of reusable launch vehicles. It is 25 percent larger than the X-40 and made of graphite/bismaleimide, a composite that can withstand higher temperatures than graphite/epoxy.

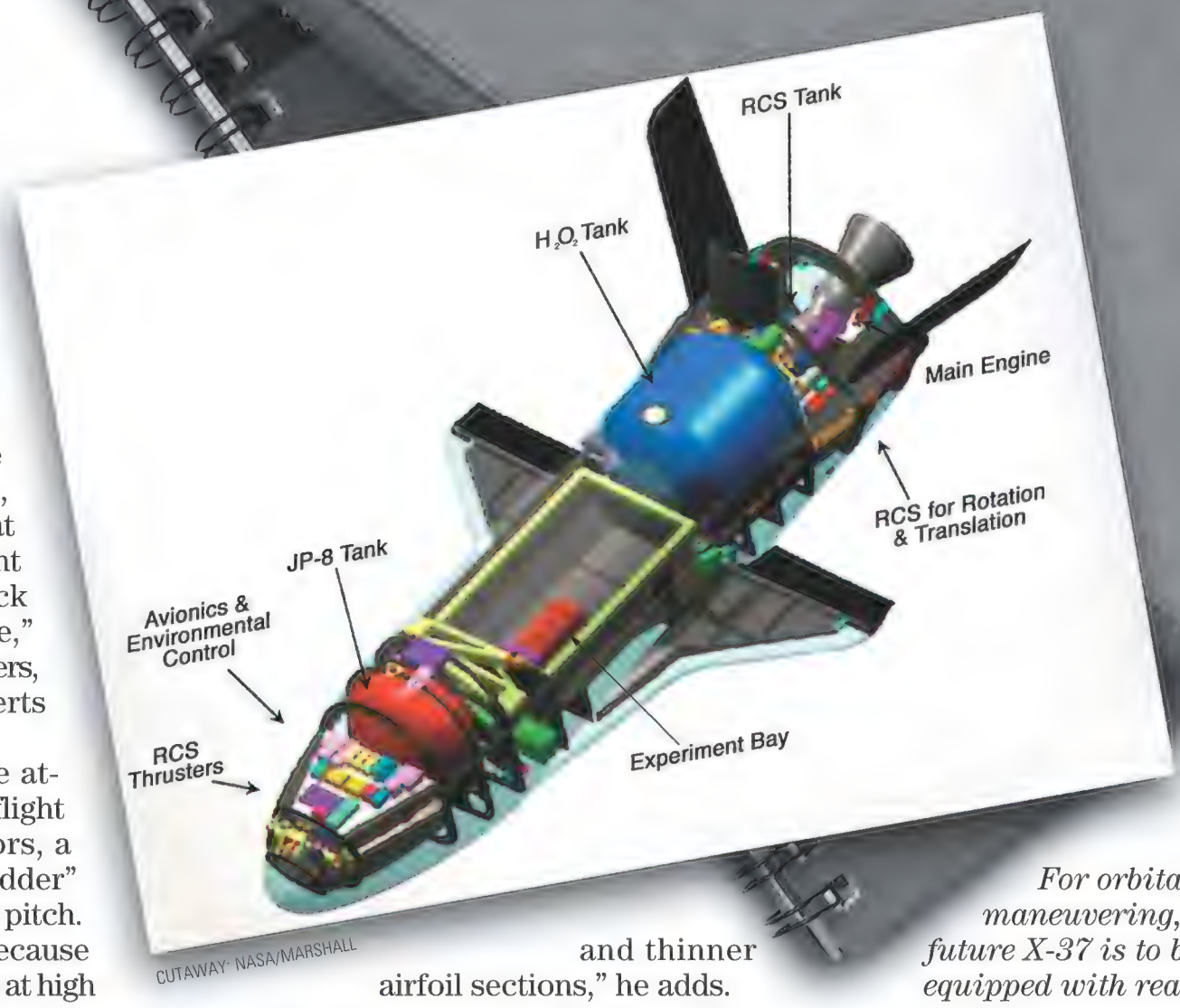
Like a Rock

The most daunting technological problem facing Boeing engineers in designing the X-40 and X-37—the problem facing any team designing a reusable spacecraft—is inventing a configuration that can achieve control through a range of flight regimes: reentry, hypersonic flight through the atmosphere, and subsonic approach and landing. "There are great debates" about the best way to land a returning spacecraft, concedes Randy Hein.

One approach to the problem is represented by an earlier NASA program. The X-38, designed as an ambulance for emergency one-way flights from the International Space Station, was a lifting body with a wedge-shaped fuselage that was slowed to land on skids by a massive 5,500-square-foot parafoil (see "Lifeboat," Aug./Sept. 1998). The two-ton space shuttle takes another approach, gliding home on delta wings, slaloming nose-up through a series of S-turns to bleed off speed. The X-40 and X-37 are shuttle-like vehicles, with stubby fuselages and small wings, all sized so that the vehicles can survive the high tempera-

NASA once considered using the space shuttle to carry the X-37 to orbit, but those plans changed. When the craft does go into space, it will most likely ride atop an expendable launcher.





CUTAWAY: NASA/MARSHALL

For orbital maneuvering, a future X-37 is to be equipped with reaction control thrusters and a Rocketdyne engine, which has been used in high-altitude tests but has never flown in space.

tures of hypersonic speeds and produce the lift needed at landing.

"We kind of refer to it as a 'lifting wing-body,' " says Arthur Grantz, Boeing's chief engineer for the X-37. While the fuselage produces more lift during the high- angle-of-attack entry phase, the wings are more important at landing and generate 60 percent of the lift. "We're more like a rock coming down than an airplane," says Boeing engineer Dave Childers, who is one of the team's experts for navigation.

For its descent through the atmosphere, the X-37 uses four flight control surfaces. Ruddervators, a combination of the words "rudder" and "elevator," control yaw and pitch. "The functions are combined because a centerline rudder is ineffective at high angles of attack [the X-37's attitude during most of its descent], and a horizontal tail and elevator would experience very high temperatures," says Grantz. The vehicle is also equipped with a body flap, a surface beneath the main engine that supplements pitch control at very high speeds.

On the wings' trailing edges, flaperons provide roll control and supplementary lift at landing. Finally, a speed brake is extended from the top of the fuselage to help control speed during the X-37's approach to the runway.

Son of Shuttle

When Boeing absorbed space shuttle builder Rockwell in 1986, it inherited Rockwell's years of experience in studying the space shuttle's landing profile. "We know the shuttle's characteristics," says X-37 program manager Al Santana, "and that helps us correlate our data and devise flight control algorithms." Santana worked on the shuttle's guidance, navigation, and control systems when the vehicle was being designed by Rockwell.

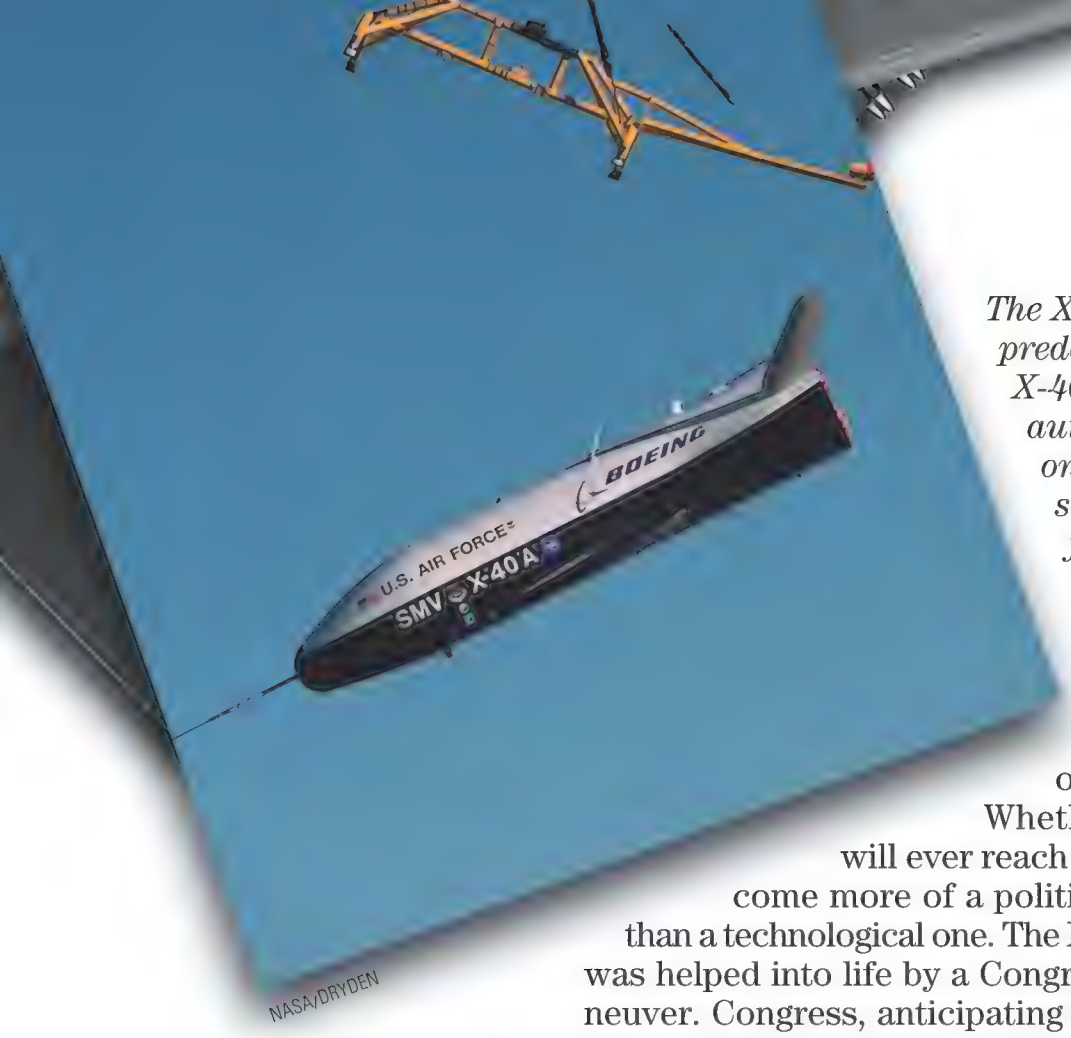
In the 21 years since the shuttle's first flight, according to Santana, the important advances for reusable spaceplanes have taken place in composite structures, thermal protection systems, and avionics. Boeing engineers are experimenting, for example, with a new heat-resistant composite material: carbon/silica carbide. Carbon/SiC, or C/SiC, can be used to form lightweight, thin control surfaces, Grantz says, that don't require the additional external insulation of ceramic tiles. "You can get aerodynamic surfaces with smaller radiuses and thinner airfoil sections," he adds.

Grantz expects the X-37 to withstand reentry temperatures even higher than those that the shuttle's ceramic-tiled skin protects it against. The surface of the X-37 will heat to 2,700 to 2,800 degrees Fahrenheit, compared with shuttle temperatures of 2,400 to 2,600 degrees, he says.

The trailing edges of the X-40's wings are an awkward-looking two inches thick because engineers assumed the X-37's trailing edges would require ceramic tiles. Now that engineers plan to use C/SiC for the flaperons and control surfaces on the ruddervators, the wing and ruddervator trailing edges will be only one inch thick.

The slenderizing of the trailing edges is a rare instance in which the X-37 has slimmed down. Program managers decided to control costs by using more off-the-shelf hardware than originally planned, and as a result, the vehicle grew heavier. Then in the early spring of 2001, the management team determined that the goals of atmospheric and orbital testing weren't as compatible as the team had first believed. The managers redefined the program's goals, confining the X-37, like the X-40, to atmospheric tests.

In 2004, the X-37 will be dropped from a B-52 at 50,000 feet to demonstrate landing and descent. Boeing is still hoping to interest NASA in a second X-37 for orbital tests as part of the agency's Space Launch Initiative, a program whose goal is to pave the way for new reusable launchers that would carry hardware and astronauts into orbit. SLI is being restructured, however, and NASA is studying a



NASA/DRYDEN

The X-37's predecessor, the X-40, landed autonomously on a runway seven times from an altitude of 15,000 feet.

number of options.

Whether the X-37 will ever reach orbit has become more of a political question than a technological one. The X-37 program was helped into life by a Congressional maneuver. Congress, anticipating trouble with NASA's X-33 single-stage-to-orbit program, added funding to the agency's 1998 appropriations to study alternative approaches to reusable launchers. The following year, the House of Representatives earmarked $20 million for NASA's participation in the Military Space Plane, reinvigorating a program that President Bill Clinton had killed with a line-item veto. The X-37 was the result of a Congressional effort to keep the Military Space Plane alive and its directive to explore alternatives to the troubled X-33. (NASA later canceled the X-33 program.)

Can This Marriage Be Saved?

The contract to develop the X-37 included Boeing's agreement to pay approximately 50 percent of the cost. The government's share included $16 million from the Air Force and the rest from NASA. The estimated cost of building and testing the vehicle ballooned from $173 million, which was to have paid for two orbital flights, to $234 million, which covers no orbital flights. But in August 2001, Air Force Secretary James Roche decided to hold the Air Force contribution at $16 million. "If it has no maneuverability because of weight growth, then you can't demonstrate the concept of maneuverability," says Colonel Mike Wolfert, a strategist in the programs and plans office at the Air Force Space Command in Colorado Springs.

Wolfert is the team leader of a joint NASA-Department of Defense panel convened to determine how the two agencies could cooperate in the future on spaceplane research. "In the past we've [demanded] too integrated a vehicle, and all we've done is set ourselves up for failure," says Wolfert.

Kevin Neifert, Boeing's director for next-generation launch systems at the Phantom Works, represented industry's point of view on the panel, which conducted a 120-day study. He believes the Air Force and NASA could collaborate on spaceplane research. "Everybody needs thermal protection systems; everybody needs autonomous control and advanced propulsion," he says.

Former Congressional staff member James Muncy isn't so sure. As a legislative assistant to Congressman Dana Rohrabacher and a staff member on the House Science Committee, he watched in frustration as the Air Force's X-40 developed into NASA's X-37. "The Air Force lost the operational concept from the program and it became a pure technology demonstrator because that's what NASA likes to build," he says.

Will the Air Force get its spaceplane?

The current administration is much friendlier to the idea of a military spaceplane than the former was. Secretary of Defense Donald Rumsfeld is presiding over what he calls a "transformation" in the armed services, a modernization process that includes developing weapons for space. Rumsfeld, while still in the private sector, led the Commission to Assess United States National Security Space Management and Organization, which, in its January 2001 report, warned of a "Space Pearl Harbor" and called for "power projection in, from and through space" and greater funding for these new capabilities. The report seemed to endorse Air Force spending for a Space Maneuver Vehicle as well as a follow-on Space Operations Vehicle, a larger spacecraft that would fly to a location in orbit and dispense a new breed of yet-to-be-developed, conventionally armed bombs.

The Rumsfeld report seemed to endorse Air Force spending for a Space Maneuver Vehicle and a larger Space Operations Vehicle, which would fly to a location in orbit and dispense conventionally armed bombs.

The Final Battlefield

The concept of space warfare, however, still has opponents both inside and outside the Department of Defense. The NASA-Air Force 120-day-study team has not released its findings because spaceplane proponents fear the multi-billion-dollar estimates alone could sink a proposal for a Space Maneuver Vehicle, according to one Air Force official. Boosting spaceplanes into orbit would be a costly way to wage war. The Space Maneuver Vehicles would lack the powerful engines required to reach orbit, so at least initially they would have to be launched atop expendable rockets, which can cost more than $100 million each. That is more than twice as much as the cost of building a single next-generation Joint Strike Fighter, which would fly hundreds of sorties. The Air Force is an enormous orga-

nization with many factions, not all of them marching in lockstep behind Rumsfeld's flag of transformation, and many leaders believe the risk inherent in spaceflight is still too great.

Outside the Pentagon, space warfare proposals are sure to spark international debate over the 1967 "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies." Better known as the Outer Space Treaty, it bars countries from using the moon or other celestial bodies as military bases. It also bars countries from launching "weapons of mass destruction" from space, though it omits mention of conventional weapons. "There are no treaty limitations here," Wolfert says.

Joanne Gabrynowicz, a space law scholar at the University of Mississippi, disagrees. The intent of the space treaty was "to ensure space [remains] a stable environment used for peaceful purposes," she says. "The goal was to not introduce the cold war to space, the horror of weapons floating around in orbit. That's just as true today."

To Wolfert and other strategists, the distinction between air-based assets and space-based assets is an arbitrary one. "I guarantee you that if people start seeing American forces dying on CNN, that policy concern will evaporate in about 10 seconds," Wolfert says.

Surface-to-air missiles "are very lethal systems," he continues. "If you wish to stay ahead, you need to be able to counter them. It's a chess game. He moves a piece. You move a piece. If you wait till that threat environment exists, it's too late."

A panel that sets Air Force missions recently urged the Pentagon's multi-service Joint Requirements Oversight Council to approve two mission-needs statements that could justify space weapons. Mission-needs statements typically precede formal White House budget requests for development of new weapons.

Meanwhile last fall, in response to Air Force interest, the Phantom Works began designing a refined spaceplane, the X-40C. It's a step back from the original, aggressive approach on the X-37. Air Force officials would be content to release a payload in orbit and safely return the vehicle to the runway in the service's first test of a reusable spaceplane. The X-40C would be launched on an expendable rocket, Wolfert says, but the timing is dependent, of course, on funding.

Boeing's Grantz is confident that the X-37 will be important in the development of any reusable vehicle that will maneuver in space. "We're thinking [the Space Maneuver Vehicle] will look very much like an X-37," he says. And although the Air Force didn't get the payload or maneuverability it wanted, if NASA and Boeing manage to finish a second X-37 and boost it toward orbit, it's hard to imagine that Air Force officials won't be watching. Unless of course they have something better hiding behind a blue curtain somewhere.

The X-37 can withstand the enormous heat of reentry—and could blaze a trail for missions described in the Rumsfeld report.

NASA/MARSHALL

WINNER TAKE ALL

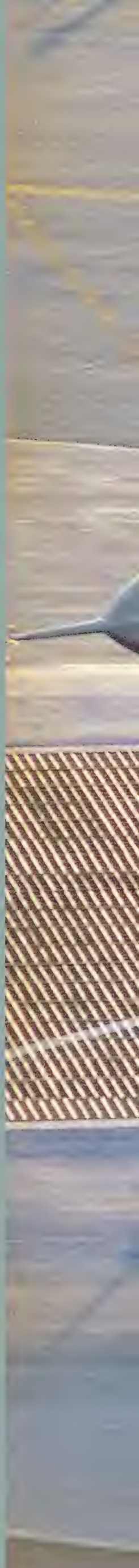
Two titans of industry slugging it out for the greatest prize in defense—the Joint Strike Fighter.

Each morning during the summer of 2000, the stillness of the Everglades was shattered by the thunder of an experimental propulsion system mounted 25 feet up on a test stand at a Pratt & Whitney facility in West Palm Beach, Florida. As the alligators stirred in the swamp, the engine roared away, hour after hour, week after week, while Lockheed Martin engineers watched nervously for signs of trouble in their intricate, classified design. All too frequently, they would shut the unit down as one mechanical problem after another dogged their efforts.

First there were oil leaks. Then, a quarter-inch misalignment of two gears produced tiny metal shavings, which worked their way into the gearbox. Bearings failed and a nut wobbled loose.

by Evan Hadingham

STEVE ZAPKA/BOEING; OPPOSITE PAGE: PETER A. TORRES/LOCKHEED MARTIN



The opponents: Boeing's welterweight X-32 (opposite), and Lockheed Martin's X-35, light on its feet (above).

DENNY LOMBARD/LOCKHEED MARTIN

PETER A. TORRES/LOCKHEED MARTIN

Foreground: the X-35A, which was later converted to the X-35B. Background: the Navy's X-35C. The lift fan was designed by Skunk Works engineer Paul Bevilaqua (inset).

In most test programs, such failures would rank as little more than minor annoyances that ingenuity and patience would surely overcome. But the continual glitches only added to the high-stakes gamble that Lockheed was already taking with its revolutionary new propulsion system: a massive lift fan weighing 1.5 tons. This was the company's daring solution to one of aviation's most daunting challenges: getting a supersonic fixed-wing airplane to take off and land vertically.

And in early 2000, the clock was ticking for the Lockheed team. At stake was a contract, worth at least $200 billion, to build the Joint Strike Fighter, a one-size-fits-all attack fighter for the Air Force, Navy, and Marine Corps. JSF program officers had already let Lockheed managers know that their chances of winning against Boeing, their rival in the competition, depended on the success of the lift fan. And Lockheed's engineers were well aware that for all the brilliance of the lift fan concept, its mechanical complexity would be its Achilles' heel.

In August 2000, propulsion and controls engineer Scott Winship received an ominous summons from Lockheed Martin's president, Dain Hancock. "Dain dragged us all into his office," Winship remembers, "because he knew that if we couldn't finish our testing on time, the customer was going to pull us from the program. All we'd have to show for it would be this neat simulation, and we'd never get to fly. I'll never forget, he said, 'I want to look everybody straight in the eye and ask if you're going to finish this program.' My first thought was *Well, maybe this is my last day at Lockheed.* At the end of the meeting he handed us the scepter and said, 'I want you to go do this!' " For Winship and his team, it was a make-or-break moment. "Thinking back, I bet half the people in the room didn't believe we could make it. And the rest, like me, who were sticking their necks out, thought *Yeah, I think we can.*"

Boeing and Lockheed Martin's epic duel began in two of Air Force Plant 42's giant hangars, separated by less than a mile of runway and Death Valley desert scrub in Palmdale, California. In one building, the home of the Skunk Works, was Lockheed Martin's team. Across the runway was a former Rockwell facility taken over by Boeing and filled with top-drawer engineering talent, some of it fresh from McDonnell Douglas after Boeing's merger with the aerospace giant in 1997. The only visitors allowed inside both facilities were JSF program officers and a crew from the Public Broadcasting System's NOVA series. (This was the first time TV access had ever been granted to a classified military development program. The NOVA documentary about the triumphs and heartbreaks of the JSF competition, on which this article is based, will air on January 14, 2003.)

The last attempt at building one fighter for both the Navy and the Air Force was in the early 1960s, when General Dynamics produced the F-111. After almost a decade of snarling, the Navy backed out of the deal, and the Air

"It needs to do everything conventional aircraft do," says Boeing's Dennis Muilenberg. "It needs to fly vertically, carry internal weapons; it has to be low-signature; and, oh, by the way, it has to be low cost and much more supportable than previous aircraft. So yeah, I was worried."

Force ended up with one of its most controversial fighters. Now Boeing and Lockheed faced the same danger: In trying to satisfy all three services, they could end up pleasing no one.

The Air Force demanded an agile and stealthy strike aircraft that would enable it to retire its F-16s. The Navy needed a replacement for its F-14s and F/A-18s sturdy enough to operate from a carrier deck. The Marine Corps was wrestling with the shortcomings of the short-takeoff-and-vertical-landing AV-8B Harrier. The Marines stipulated that, unlike the Harrier, their STOVL version of JSF had to be stealthy, supersonic, and able to bring back a 5,000-pound payload at the end of a mission. "When I took an initial look at the requirements," recalls Boeing's chief designer, Dennis Muilenberg, "it worried me. It was by far the most difficult set of requirements I've ever seen. It needs to do everything that conventional aircraft do. It needs to fly vertically, carry internal weapons; it also has to be low-signature; and, oh, by the way, it has to be very low cost and be much more supportable than previous aircraft. So yeah, I was worried."

To overcome their greatest worry—STOVL capability—Muilenberg and his team chose the simplest, cheapest solution that had already been tested by an operational aircraft: the direct lift approach, pioneered by the British Aerospace Harrier. A direct lift system redirects the thrust from the engine through a series of downward-pointing nozzles on takeoff and landing. Muilenberg's design involved channeling most of the thrust through two main lift nozzles close to the center of gravity, while additional nozzles at the wingtips and tail would help control the airplane's attitude. Digital flight controls would manage the job of coordinating the hover control, eliminating the tricky handling that had made the Harrier such a nightmare for neophyte pilots.

But other drawbacks of the Harrier approach were not so easy to overcome. The total reliance on the engine for lift in takeoff and landing meant that weight was always a crucial factor. "Boeing was the first to get the cost message," says *Flight International* reporter Graham Warwick, "and the simplicity of direct lift gave them a great rationale. But like the Harrier, their plane's STOVL performance always depended on the engine. They were always asking for more thrust from the engine than Lockheed, and always fighting weight from day one. Though every aircraft test program fights weight, for Boeing it became their most critical factor."

Lockheed's solution to STOVL was the lift fan, a groundbreaking design that brought with it different kinds of headaches. The concept dates to 1987, when officials from the U.S. government's Defense Advanced Research Projects Agency asked Skunk Works engineer Paul Bevilaqua to come up with a way to improve the Harrier's performance. In his subsequent patent, Bevilaqua sketched out his idea: installing a pair of horizontal, counter-rotating fans that would provide a pillar of air for the airplane to hover and land on, in addition to the vectored thrust from the engine. But what would drive this extra source of lift? Bevilaqua had a "Eureka!" moment when he figured out an efficient way to extract additional power from the engine. This power was transferred to the lift fan by a drive shaft that projected from the front of the engine. The drive shaft had to make a 90-degree turn to the horizontal fan via a clutch

The lift fan that transformed the X-35 from a conventional-takeoff-and-landing aircraft to a short-takeoff-vertical-lander is installed in the circular bay behind the cockpit. A straight duct was replaced with a three-bearing swivel duct on the aft end of the Pratt & Whitney engine (used on all versions of the X-35).

PETER A. TORRES/LOCKHEED MARTIN

and gearbox similar, in principle, to those of an automobile.

Bevilaqua's back-of-the-envelope calculations suggested that the drive shaft could supply a phenomenal 28,000 horsepower, enough to make the lift fan support nearly half the hovering weight of the airplane. "Several of my colleagues sat up and said 'Holy smoke!' " chief engineer Rick Rezabeck recalls, " 'You're going to have 28,000 shaft horsepower running through the middle of a fighter jet.' That's about half the level that the Navy puts through the shaft of a destroyer. So the whole question was: Would it hold itself together and could we make it mechanically and structurally sound enough so it was reliable and added up to a viable jet fighter?"

"We're dead in the water!" For nearly a year, Boeing engineer George Bible had been experimenting with a novel composite material for the delta wing of the JSF, a project that grew out of a series of Boeing decisions to make sturdy and cost-efficient components for its new fighter.

The concept was a winner: Build the wing as a rugged, one-piece metal structure, sandwiched by two layers of composite—an upper skin and a lower skin. To make the skins more durable, Boeing would embed carbon fibers in an advanced thermoplastic resin. But no one had tried to build a wing skin 30 feet across from a single piece of thermoplastic. Now, as Bible stared at his ultrasound monitor, it was clear that the skin was riddled with bubbles.

The experiment had begun encouragingly enough. Bible's team had spent weeks laying down sheets of carbon fiber into resin until the wing skin was 90 sheets deep but still less than an inch thick. It was then cured in a massive oven-like autoclave under high pressure, which forced the fibers to blend with the resin. Emerging from the oven, the quality of the first upper skin seemed to bode well for Boeing's gamble. But the lower skin had a more complex shape, and patches of the material ended up sticking to the mold. One of the advantages of working with thermoplastic is that it can be "re-cooked" if defects show up in the manufacturing. Bible's team added more release agent—similar to cooking spray—to the mold and tried again. This time the skin didn't stick but the pressure hoses leaked, and out came the bubble-ridden mess that had distressed Bible.

Bible launched a desperate effort to make the advanced resin pay off: If he cooked the wing yet again, perhaps the bubbles would disappear. For 30 hours the team members held their breath. Gingerly, they peeled away the orange pressure bags—and Bible's face fell. Patches were still sticking to the mold, and there were wrinkles where the resin had been compressed unevenly. Now Bible felt as if the weight of the whole JSF program was on his back. "If we don't have a wing skin, we don't have an airplane," he said. "We don't make first flight—it's pretty much 'game over.' "

In June 2001, the Marine Corps X-35B passed its water test, which checked for turbulence from the lift fan.

PETER A. TORRES/LOCKHEED MARTIN

Before the X-35A's first flight, Lockheed ran the Pratt & Whitney JSF119-611 engine up to full afterburner, creating a light show at the company's Palmdale facility in California.

As the wing-skin crew struggled, Boeing's main design team wrestled with its own crisis. The Navy had come back with new demands for performance and weapons-carrying capability. Flight simulators revealed that, with the extra weight on its delta wing, Boeing's airplane could no longer meet the Navy's demands. For months, the engineers worked on various fixes. Some sparked protracted debate, notably a design for a novel tail configuration advanced by a former Mc-

PETER A. TORRES/MARTY WOLIN/LOCKHEED MARTIN

Donnell Douglas engineer, Ralph Pelikan. A normal four-post fighter tail layout features a twin pair of tail surfaces. The Pelikan tail would replace this conventional layout with a striking two-post layout in which just two angled tail surfaces controlled both pitch and yaw.

In October 1998, top Boeing designers weighed the advantages and penalties of Pelikan's design. One argued that it offered greater pitch control at high angles of attack. Then the stealth experts pointed out that two tails would have a lower radar signature than four. "We can't afford to have any question at all over our signature," argued Fred May. "I vote for the Pelikan tail."

But another engineer came up with a surprising objection: Despite the fact that the Pelikan tail would eliminate the need for two control surfaces, it might actually end up heavier. The bigger hydraulic pumps and cylinders needed to operate the larger surfaces would end up adding at least 200 pounds to the design. Meanwhile, team leader Dennis Muilenberg was worried about customer perception. He believed that the JSF office viewed Lockheed's conventional four-post tail as a low-risk approach. Should Boeing also go with a tried-and-true design? "On the other hand," he added, "if we end up looking like we're the followers and Lockheed's the leader, it might be a strategically bad thing."

Eventually it fell to Muilenberg to break the stalemate. Despite earlier doubts, he concluded, "We need to do something to our configuration that will give us an advantage. I think the Pelikan tail does that. We're going to have to work the hell out of weight, but I can't imagine anyone better at doing that than the Boeing team."

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But days later, Muilenberg's team reversed its decision. Fresh analysis suggested that the weight penalty of the Pelikan tail might be more like 800 or 900 pounds, and this and other factors tipped the balance in favor of a conventional four-post tail.

Back in Seattle, another key decision put an end to George Bible's agony. After the third thermoplastic failure, he was told to abandon what Boeing had hoped would be a competitive edge over Lockheed, and revert to more con-

The X-35 "fastener-less" inlet duct, made of graphite-epoxy composite, curves to prevent radar reflection from the engine.

PETER A. TORRES/LOCKHEED MARTIN

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ventional—thermoset—material. His exhausted crew cooked up the required wing skins without a hitch. "It's just a good feeling being done with them," Bible said as he watched them being loaded on to a C-5 Galaxy. "They were quite a pain." The Galaxy roared into the sky over Seattle and delivered the wing skins, more or less on time and on budget, to the Boeing assembly line at Palmdale.

While Bible was struggling with his unruly resins, Lockheed faced its ultimate trial by fire. In early 1999, the first of five test lift fans was hoisted onto the giant Pratt & Whitney test rig overlooking the Florida swamps. As the engine roared day and night, test data was e-mailed daily back to Palmdale, where the engineers would compare results with the predictions of their flight control simulators.

Although the constant mechanical glitches that plagued the tests were highly visible to the media, they were never the real threat, according to engineer Scott Winship. "I always had faith we could solve those kinds of problems," he says. "What I didn't know was whether we would succeed in integrating the flight controls we needed to make this huge fire-breathing beast behave. And while we were having all these mechanical problems, the flight controls testing kept getting delayed and we had still not done the hundreds of hours of tests we needed to write the code that makes the airplane fly. The program was squeezed—we just couldn't get enough data for our answers. So the whole schedule started slipping."

Home sweet home!" exclaimed Boeing chief test pilot Fred Knox as he clambered into the cockpit. It was shortly before 8 a.m. on September 18, 2000, and on the runway at Palmdale, Boeing's first demonstrator, the X-32A, was on the brink of its maiden flight. This morning, Knox's mission was to fly the X-32A, with landing gear down, to Edwards Air Force Base, half an hour away, where it would undergo another five months of flight trials.

Knox flipped a switch and the engine roared to life. At the edge of the runway, Boeing engineers cheered. "Very shortly after liftoff," Knox said, "it was absolutely clear to me that I was flying the airplane we had designed, built, and that I had been simulating for several years."

Dennis O'Donoghue, a second JSF test pilot, following behind Knox in an F/A-18, was in shock. "Fred was flying at military power with no afterburner," he said. "But he started climbing like a rocket. It was incredible: He was just gone. I had to use full afterburner, and I only caught up with him at 10,000 feet." Although the X-32A sprang a hydraulic leak and was ordered back to Palmdale, the test program was off to an auspicious start.

A month later, Lockheed caught up as its demonstrator, the X-35A, got off the ground. But the most crucial flight trial confronted Lockheed the following summer. Early on Sunday, June 24, 2001, JSF program manager Rick Baker nervously joined the lift fan's godfather, Paul Bevilaqua, and its two key problem-solvers, Winship and Rezabeck, at the edge of the Palmdale runway. Former Harrier pilot Simon Hargreaves, a British test pilot, was about to nurse the X-35B STOVL version and its lift fan into the air for the first time.

"At the time, we were just supposed to be doing 'press-ups,' where Simon was going up to only five feet," says Baker. "And he did five feet—we watched the wheels come off the ground and my heart started beating faster. Then he went up 10 feet and came down again so we could measure things like fuel temperature and heat. And then he went up and up to 50 feet and he held it. We looked at each other and said, 'The Skunks did it again!' and we hugged everybody. That was the real turning point. We knew the magic of the Skunk Works was still there."

The lift fan's success dashed Boeing's hopes of an easy JSF victory. Yet the very same day at the testing base at Naval Air Station Patuxent River in Maryland, Boeing's X-32A completed its first hover. As flight testing continued, with Boeing sometimes flying five missions a day and performing nearly flawlessly, the competition remained too close to call. Only a major slip would make one team the obvious winner.

Boeing's X-32 (left) and Lockheed Martin's X-35 debut on Media Day in November 2000 at Edwards Air Force Base in California.

At 1,500 feet over Patuxent River, Dennis O'Donoghue turned the X-32B downwind to prepare for its first vertical landing. As he brought Boeing's STOVL demonstrator down to a stable hover at around 150 feet, he flicked a switch that turned on the jet screen—a narrow slot under the fuselage that blew cool engine bleed air toward the ground, helping to balance the airplane in hover and prevent the engine from sucking in its own exhaust.

By now brimming with confidence in the demonstrator's handling qualities, O'Donoghue brought the X-32B gently down over the hover pit, a cavity in the runway designed to keep the exhaust from blowing back into the engine and minimize ground effect. The airplane coasted down to 40 feet, then O'Donoghue abruptly felt the bottom drop out underneath him. He jammed the throttle full forward and a red engine light flicked on, the automated voice he had hoped never to hear barking: "Warning, Warning, Engine, Engine." Red lights were flashing in the control room too, and flight controller Howard Gofus tensely ordered O'Donoghue to abort the landing. But O'Donoghue was already at full power, and there was nothing more he could do. Bracing himself for a crash, he radioed, "I'm coming down!"

Then, with only seconds to spare, he got a reprieve. With around 20 feet to go, the engine recovered and the cockpit warnings ceased. The X-32B slowed its descent until it made a gentle touchdown at almost precisely its targeted landing speed. For the onlookers who rushed forward to congratulate O'Donoghue, it appeared to be a normal landing. Only Gofus and his team in the tower knew about the close shave, and they quickly figured out what the problem was. The wind that normally helped clear exhaust from the hover pit had momentarily died, and as the X-32B came down, its own exhaust gases had risen up from the walls of the pit and been sucked into the engine.

Confident in the diagnosis, Gofus went ahead with a second landing over a normal runway surface. O'Donoghue touched down without incident.

One week later, pilot Paul Stone of Britain's Royal Navy took O'Donoghue's place for another test: the X-32B's first vertical takeoff. The flight plan called for a vertical landing followed immediately by a vertical takeoff. As Stone brought the airplane down gently, with the tires almost touching the runway, it wobbled momentarily, then a bright flash and a loud pop went off underneath the fuselage. Once again, hot exhaust had been sucked into the engine, and this time had caused a split-second engine "pop stall."

HEATHER GREASLEY/LOCKHEED MARTIN

The X-35B lifts off the hover pit with its nozzle vectored for short-takeoff-vertical-landing. To convert the engine's operation from conventional takeoff to STOVL, the pilot moves a lever back about an inch. This opens four sets of doors behind the cockpit, allowing air to flow through the lift fan and starting the nozzle moving through its full range of travel. Simultaneously a clutch engages, transferring power from the engine to the lift fan.

TOM REYNOLDS/LOCKHEED MARTIN

With the announcement that Lockheed had won the face-off, the company again demonstrated its specialties: speed, stealth, and salesmanship.

The media were quick to seize on the episode, but O'Donoghue was unruffled. "All of us who worked with Harriers knew what that pop stall was and it was no big deal," he says. "In fact, our simulations had predicted exactly what happened: If the plane tilted more than four degrees near the ground, the jet screen would no longer protect the engine and a stall would likely follow. We had already fixed the problem in our final design proposal with a bigger jet screen."

As far as the Boeing team was concerned, the pop stall had been a nonevent, but the members knew it hadn't looked good. Perception is everything, and the episode was a reminder of other inherent drawbacks that direct lift had and Lockheed's fan didn't. As with the Harrier, the 1,350-degree heat of the Boeing airplane's exhaust gases would pose a threat to the surface of carrier decks, if not to the life and limb of Navy crews (the downdraft from Lockheed's lift fan was some 1,000 degrees cooler). Since Lockheed's fan boosted engine thrust, its powerplant could run at lower temperature and with less strain, and these differences would translate into longer life. Most significant, assuming its reliability could be ensured, the lift fan would offer an extra margin of power and safety in a hover. In the end, that ensured Lockheed's victory.

The record of the flight tests offers an important clue to why Lockheed won. At the program's conclusion, the X-35B had performed 38 STOVL flights, most at Edwards Air Force Base at an altitude of 2,500 feet. In contrast, Boeing's X-32B had flown 57 STOVL flights, but these were all at the sea-level Patuxent River Naval Air Station. Despite the altitude advantage, the Boeing airplane flew with its inlet cowl and undercarriage doors removed to increase the thrust-to-weight margin. ("I would have left my underwear home that day," says O'Donoghue.)

"In my mind, it was physics versus technology," says Lockheed test pilot Paul Smith. "In the area of STOVL performance, Boeing just didn't have the physics behind them—they didn't have the thrust of the engine up and the weight of the airplane down, while we had a technology that made efficient use of engine power, but it was so technologically advanced that it was touch-and-go whether it would work. A month before we were supposed to demonstrate STOVL, we were still having problems with the lift fan that we thought we might not be able to fix. Boeing had done so many cool things, and were ahead of us on schedule so much. It was like the tortoise and the hare."

On October 26, 2001, several hundred members of the Lockheed Martin team gathered in the X-35 hangar at Palmdale. On a big-screen TV, the Pentagon announced the company's victory, causing the team to erupt in deafening cheers. "We did as much as we needed to win this thing," an ecstatic Rezabeck told NOVA. "We were very comfortably—anxiously and nervously—confident!" In a contest in which both sides had displayed astonishing inventiveness, Lockheed had taken the bigger risk. And if the reliability of Bevilaqua's lift fan has yet to be proven, it seemed reliable enough to win Lockheed the biggest military contract of the new century.

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SIGHTINGS

As the publisher and chief photographer for *Pilot Getaways* magazine, George A. Kounis introduces pilots to new destinations. "A shot that includes an airplane on approach to the airport places you there," he says. "To me, looking at these photos is like seeing the beginning of a story unfold. Readers tell me these pictures make them stop and think: *What adventures will I have when I follow this same approach and land there?*"

Four beginnings: An Aviat Husky aims for a 1,800-foot dirt strip at Deadwood Reservoir in Idaho (right); a Cessna Cardinal RG turns final for a more spacious paved strip at Cal Black Memorial airport in Halls Crossing, Utah (below); a Travel Air 4000 heads for Tillamook airport in Oregon, where an old blimp hangar houses an air museum (opposite, top); and a Piper Cherokee lines up for Johnson Creek grass strip in Idaho backcountry (opposite, bottom).


NC4949

"Genghis John"

Boyd: The Fighter Pilot Who Changed the Art of War

by Robert Coram. Little, Brown, 2002. 496 pp., $27.95.

Questioning General Norman Schwarzkopf's initial Desert Storm battle plan, a "head-to-head assault against the main strength of the Iraqi forces," then-Secretary of Defense Dick Cheney summoned John R. Boyd, a retired Air Force colonel, for extended consultation.

The subsequent Marine Corps amphibious feint toward Kuwait, followed by a successful Army left-hook attack through the desert, was, writes Robert Coram, a direct reflection of Boyd's theories. Indeed, Marine Corps Commandant Charles Krulak's 1997 tribute hailed Boyd as an "architect of America's victory in the Gulf War."

In this fascinating biography, Robert Coram captures the dazzling diversity of John Boyd—fighter pilot, aerial tactician, engineer, and scholar. Author of 10 books and a reporter at the *Atlanta Journal-Constitution*, Coram limns the life of "the most famous fighter pilot in the world," a man who "rarely met a general he couldn't offend" and who unabashedly told a military contractor that his proposed aircraft had to be "made out of balonium."

From Boyd's Depression-era childhood in Erie, Pennsylvania, Coram takes us to MiG Alley in Korea and back to the furball world of the U.S. Air Force Fighter Weapons School, where "Forty-Second Boyd" (the time it took him to best an aerial opponent) enjoyed rat-racing, skunk fights, and hosing fighter pilots in the skies over Nellis Air Force Base in Nevada. The book moves on to the halls of the Pentagon, where Boyd's theories energized the "Fighter Mafia," who redesigned the F-15 and conceived today's ubiquitous F-16 lightweight fighter. Back then, generals and admirals resisted Boyd-think, but lower-echelon officers, especially in the Marine Corps, espoused his principles. Now they've caught on with some of the leadership as well.

COURTESY MARY E. HOLTON

Precursors of Boyd's ideas appeared in 1942, when U.S. Admiral Raymond Spruance got inside the decision cycle of Japan's Admiral Chuichi Nagumo and launched his airplanes early in the Battle of Midway. Another precursor came in 1943, when Soviet ace Aleksandr Pokryshkin introduced "bookshelf" formations enabling his P-39 squadrons to control the vertical plane, providing speed, altitude, and maneuverability options as the squadrons bounced approaching German ground-support aircraft.

Later, during the cold war, Boyd explored, expanded, and codified such intuitive concepts. He taught himself calculus and, after experiencing an epiphany while studying for a thermodynamics exam, worked out the mathematics for his Energy-Maneuverability Theory. Coram tells how Boyd subsequently proved that most Soviet fighters possessed dogfighting capabilities superior to those of their U.S. counterparts—that the Soviet aircraft could outmaneuver the F-111, for example, throughout its entire flight envelope.

Today, reverberations from Boyd's landmark study "time-based theory of conflict" continue to be felt. Management guru Tom Peters, author of *Thriving on Chaos*, acknowledges Boyd's influence on his writing and his impact on corporate strategies. And in the recently published book *Tank*, author Patrick Wright, discussing the agility of the Future Main Battle Tank, writes that "the point of these 'quick high tempo operations' is to do everything so speedily that you're 'inside the enemy's decision cycle.' " Straight from Boyd, but not credited in text, index, or acknowledgments. That his revolutionary thinking has become generic is the highest compliment it could receive.

Despite Boyd's numerous awards and a combination of acumen and unwavering honesty that inspired others to shake up Pentagon weapons testing programs and procurement procedures, his lack of people skills would impede his promotions. Similarly, his obsessive work ethic devastated family relations. In that grim context, Coram's description of daughter Mary Ellen's final moments with her dying father is incredibly moving.

A few minor glitches: "the World War II B-50" first flew in 1947—and did not participate in Korean War B-29 bombing

missions. Nor was the 1960s Marine Corps still teaching recruits "the concept of advancing on line," an outmoded practice replaced by squad-based fire-and-maneuver derived from German army tactics at the close of World War I. McDonnell's F-101 served as a long-range interceptor, not "an escort for [Strategic Air Command] bombers."

Nonetheless, the book captures the essence of John Boyd, who got internal cannon put back into fighters, whose *Aerial Attack Study* became the official Air Force fighter tactics teaching manual, and who also generated an innovative paradigm for structuring military operations in our post-cold war world.
—Lee Gaillard writes about military issues and technology for Defense News, *the* San Francisco Chronicle, *and* U.S. Naval Institute Proceedings.

Billy Mitchell

by James J. Cooke. Lynne Rienner Publishers, 2002. 305 pp., $49.95.

James J. Cooke, emeritus professor of history at the University of Mississippi, has done much to clarify U. S. aviation in World War I. In *The U.S. Air Service in the Great War, 1917–1919* (1996), he presented U.S. aviation, including the observation, bombing, and balloon units, as part of a coordinated military effort. Cooke's work brought a historian's perspective to the story of the over-glamorized pursuit squadrons.

In *Billy Mitchell*, Cooke adds dimension to an aviation legend. He is unfailingly even-handed in his treatment of Mitchell—who rarely accorded such fairness to others. Cooke's many sources range from trial transcripts to Mitchell family papers—notably correspondence between Mitchell and his mother—and he draws the richest picture of Mitchell yet seen.

Outside the U.S. Air Force and aviation enthusiasts, Billy Mitchell is all but unknown today, but he once mesmerized the public. He orchestrated much of the U.S. aviation success in World War I, including the nation's first strategic bombing effort. He demonstrated that airplanes could sink battleships. He called for a unified air service and for a department of defense that would unite the nation's air, land, and sea forces under a single cabinet officer. Cooke demonstrates, however, that Mitchell's prescience was marred by a mulish conviction that only Billy Mitchell could head such a department.

Mitchell's battleship-baiting and demands for an independent air service infuriated Army and Navy traditionalists. Mitchell testified before several Congressional committees, and on each occasion he let fly at his superiors. Cooke notes that Mitchell's constant sweeping criticisms, with the signal exception of a critique of Pacific air defenses, frequently overlooked facts.

In the wake of the 1925 wreck of the Navy dirigible *Shenandoah*, Mitchell issued a 6,000-word statement containing this sentence: "These accidents are the result of the incompetency, the criminal negligence, and the almost treasonable administration of our national defense by the Navy and War Departments." To no one's surprise, the insubordinate statement led to his arrest and court-martial. The court found Mitchell guilty and suspended him from the Army. He resigned his commission in February 1926, but continued writing and speaking—with diminishing effectiveness—until his death in 1936.

But what of Mitchell the person? Cooke humanizes him, though the process is painful. He explores in depth Mitchell's ugly divorce from his first wife, his constant financial troubles, and his fiscal dependency on both his mother and his second wife. We read also of Mitchell's drinking problems, his estrangement from his first three children, his unwillingness to cooperate with anyone who could not further his causes, his often slipshod work as a writer, and his constant willingness to ignore or twist reality.

The 1955 film *The Court Martial of Billy Mitchell* presents Mitchell as an apolitical, visionary saint. Cooke shows that he was nothing of the kind. His wealthy grandfather was well connected politically, and his father served Wisconsin as both a Congressman and U.S. Senator. Mitchell understood and used political clout from the moment he donned an Army uniform in 1898. Cooke brings to life a man often called a founder of the modern U.S. Air Force and, in so doing, reminds us that even a crusade can benefit from a bit of restraint. *Billy Mitchell* is the story of a man who had none.
—William Jeanes lives in Pass Christian, Mississippi, and is a former editor-in-chief of Car and Driver.

THE INSIDE STORY

Air Force One

by Robert F. Dorr. MBI Publishing Company, 2002. 156 pp., $29.95.

Aircraft historian (and frequent contributor to Reviews & Previews) Robert F. Dorr has compiled a meticulously detailed and gossipy book on the U.S. presidents' aircraft—focusing on the Boeing 747 in use since 1990, but covering all the craft associated with the 89th Airlift Wing and the Presidential Airlift Group. That includes the three Grumman Gulfstream IIIs charged with transporting high-ranking government executives in the event of a nuclear attack (the aircraft have instruments impervious to the electromagnetic pulse generated by a nuclear detonation); the 757 that serves the vice president; and Marine One, the Sikorsky VH-60N Presidential helicopter.

The history section is rich with nostalgic photos. It opens with a duck-out-of-water shot of a Boeing B-314 flying boat (a sister ship of a -314 that once carried Franklin Roosevelt) on a dolly on a ramp. Equally pleasing is a 1957 photo of a "Flying Banana" H-21 helicopter touching down on a softball field opposite the White House.

Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas About Strategic Bombing, 1914–1945

by Tami Davis Biddle. Princeton University Press, 2002. 408 pp., $45.00.

Given her subtitle, it's probably unfair to fault Tami Davis Biddle for not including Germany and Japan in her study. Still, to read *Rhetoric and Reality* 60 years after history's first "thousand-plane" raid (the Royal Air Force's strike against Cologne on the night of May 30, 1942) is like combing the hair over the bald spot at the back of your head when all you can see is your face in the mirror. The book has no bibliography as such, but it does have splendid notes, and from them I conclude that Biddle's only source on the German air force was James Corum's *The Luftwaffe*, published by the University Press of Kansas. With all due respect to Corum, this is working at a considerable remove.

Within this handicap, Biddle has done an exhaustive job of investigating how bombing theory evolved. The United

States and Great Britain, along with most of the rest of the world, believed that air power could destroy an enemy's will to fight. In Britain, Sir Arthur Harris of Bomber Command assured politicians that his Lancasters would make an invasion of Germany quite unnecessary.

The Americans never went that far, Biddle asserts, but the difference was in the details. The thin-skinned Lancaster could survive over Germany only at night, when bombing aids were mostly useless, forcing Harris to target city centers. The B-17 Flying Fortress carried fewer bombs but more guns and armor, and the Norden bombsight was reasonably accurate, so the Americans chose to attack specific factories and other facilities by daylight, trusting the bombers to fight their way to the target and back. In the end, she notes, the two strategies more or less converged. The British developed a good radar bombsight, while the Americans were forced (by weather and by their own huge quantities of airplanes) to adopt "saturation bombing." And over Japan, the B-29s prevailed only after Air Force General Curtis LeMay sent them in low, at night, to burn out whole cities.

This would have been an even more useful book if Biddle had paid a bit more attention to the nitty-gritty. She's incorrect, for example, in asserting that the Americans failed to develop external fuel tanks and thus didn't get a long-range escort fighter until 1943. Drop tanks were incorporated into U.S. fighter designs by 1941, when the United States entered the war, and early P-51s could carry two. They didn't suffice. Not until the P-51B was given an extra fuselage tank could it shepherd bombers to Germany and back.

—Daniel Ford's latest book is a new edition of The Lady and the Tigers, *detailing Olga Greenlaw's year with the American Volunteer Group.*

We Have Capture

by Thomas P. Stafford with Michael Cassut. Smithsonian Institution Press, 2002. 271 pp., $29.95.

He achieved the first-ever spacecraft rendezvous. He commanded Apollo 10, which paved the way for the first lunar landing. He holds the record for the highest speed attained by man, more than 28,000 mph. He met presidents, even taking the place of Richard Nixon at a cosmonaut's funeral. He gave a "handshake in space" in the first international docking of the Americans and the Soviets. He drafted the original specifications for the B-2 stealth bomber. It seemed the only thing left for Lieutenant General Thomas P. Stafford (ret.) to accomplish was to write about these achievements. In *We Have Capture*, Stafford, along with Michael Cassut, tells of all this and other details in a memoir of an amazing career during the height of the space race and beyond.

From humble beginnings in the Oklahoma plains, through the rigors of the Naval Academy, around the world with the Air Force and NASA, and into space, Stafford takes the reader through his adventures and milestones. Despite his successes, he has a refreshing air of humility, and it seems as though he writes to reminisce rather than boast.

In telling about his life and career with NASA and his collaboration on Soviet space programs, the Astronaut Hall of Famer manages to walk the fine line between professional and personal, astronaut and cosmonaut, technical and general knowledge, making only a few slips. Stafford does not compromise his exceptional level of detail, even providing down-to-the-minute retellings of stories from decades past, but he makes a concerted effort to avoid acronyms when discussing his involvement with space programs and hardware. This means the text, at times, bogs down with minutiae, but all things considered, Stafford's stories make up tenfold in detail what they sometimes lose in pace.

—Mark Greer will graduate from the Medill School of Journalism in Evanston, Illinois, in 2003.

Before Amelia: Women Pilots in the Early Days of Aviation

by Eileen F. Lebow. Brassey's, Inc, 2002. 315 pp., $26.95.

The Tomboy of the Air. The Winged Suffragette. The Fiancée of Danger. That's how women pilots were known in the days before World War I, when an airplane cockpit consisted of "a bucket seat fastened to a ladder on the lower wing." Eileen Lebow, author of books about the Army Balloon Corps and the *Vin Fiz*, here gives the little-known history of the first women fliers, some five dozen from 10 countries.

Many of their stories are similar: Facing male prejudice, former motorcycle riders learn to fly along with their husbands. And because the biographies appear one at a time, details often get repeated—especially in the case

COMING ATTRACTION

Star Trek: Nemesis

The starship Enterprise-E *encounters a new and more formidable class of Romulan war vessels in* Star Trek: Nemesis *from Paramount, opening December 13. Jean-Luc Picard and crew are sent to Romulus to follow up on a peace feeler from the Federation's sworn enemy. Once inside the Romulan sphere of influence, they meet up with an apparent mirror-image—and evil—universe.*

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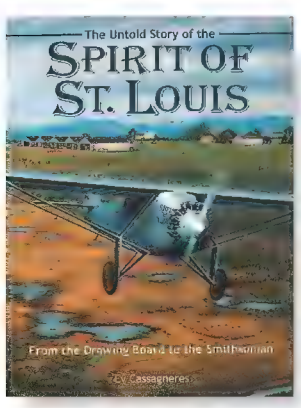
of American sisters Katherine and Marjorie Stinson. But the cast of characters includes enough variety to keep things interesting. For instance, France's third female pilot, Marie Marvingt, was also the country's best woman swimmer, a skiing champion, one of the few bike riders who finished the 1908 Tour de France, a skilled circus performer, and the first woman to pilot a balloon across the North Sea.

Aircraft manufacturers like Anthony Fokker and Henry Farman were charitable toward female fliers, reasoning that their smaller size and lighter weight, plus more dexterous hands, made them more capable than men. (Also important for safety's sake, women pilots drank less than men did.) But when Ruth Law, America's sixth female pilot, tried to enroll in the Wright School, Orville refused to teach her. (He did sell her an airplane.) Law lived to be 83, typical of these daring women born in the 1870s and 1880s, most of whom survived the early days of flight and lived on into the 1960s and 1970s.
—Richard Sassaman is a frequent contributor to Air & Space/Smithsonian.

The Untold Story of the *Spirit of St. Louis*: From the Drawing Board to the Smithsonian

by Ev Cassagneres. Flying Books International, 2002. 176 pp., $19.95.

A man possessed, Ev Cassagneres has spent 35 years researching Charles Lindbergh's airplane, as well as his transatlantic and subsequent flights. The result is an exhaustive compilation: how the earth inductor compass worked, who made the pilot's seat of woven wicker and brown velveteen, the numbers and price of each oceanic chart Lindbergh used. I learned that Lindbergh's first book, titled *We*, referred not to the author and his airplane but rather to Lindbergh and his investors in St. Louis. And what of the mirror a young woman gave Lindbergh before his transatlantic trip, which he used to read the compass? On an inspection of the airplane at the National Air and Space Museum, Cassagneres took the mirror off the instrument panel and found the name "Starrett Tools" on the back—surely not the mirror the woman fished from her purse. Cassagneres tracked down the Starrett company and deduced that somewhere along the line, a mechanic took the original for a souvenir and replaced it with one from his toolbox.
—Patricia Trenner is a senior editor at Air & Space/Smithsonian.



IN BRIEF

A Tribble's Guide to Space: How to Get to Space and What to Do When You're There

by Alan C. Tribble, Princeton University Press, 2002. 200 pp., $16.95.

In the style of the "...for Dummies" series, this chatty tutorial by an actual rocket scientist tackles everything from theories of relativity to the history of space exploration, explaining things in language anyone can understand.

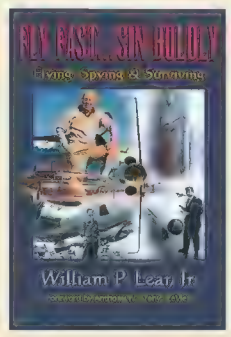
Air Carrier Operations

by Mark J. Holt and Phillip J. Poynor. Iowa State Press, 2002. 324 pp., $39.99.

This textbook-*cum*-manual covers the Federal Aviation Regulations that govern airlines and their managers, complete with quizzes and exercises following each chapter. Thinking of starting up the next Southwest? Start here.

Fly Fast...Sin Boldly

Flying, Spying & Surviving by William P. Lear Jr. Addax Publishing Group, 2002. 475 pp., $27.95.



An autobiography by the son of the famed Learjet developer is part confessional and part scrapbook. This volume should provide an excellent test of the statute of limitations in several states.

CREDITS

Yawning Across the Atlantic. Russell Gregory now flies the Atlantic in a Boeing 767 for a major airline. He misses pulling Gs, but there is no substitute for a bathroom on an eight-hour flight.

Profiled. Helen Cota was an air traffic controller for 15 years. Now she and her husband are freelance writers.

In Search of the Real Wright Flyer. Phaedra Hise is a freelance journalist, private pilot, and author of *Pilot Error: Anatomy of a Plane Crash* (Brassey's, 2002).

More Flyers.. Roger Mola is a frequent contributor to *Air & Space/Smithsonian.*

White Elephant. Tom Harpole has been reporting stories from Russia and the former Soviet Union since 1989.

Restoration: Going the Distance. Phil Scott writes from Manhattan, and he's a big fan of Floyd Bennett Field.

CorsairFest. Larry Lowe has written for *Air & Space* about air racing and competition aerobatics.

Photographer Erik Hildebrandt has just completed his third coffee-table book, about the U.S. Air Force's Heritage Flight.

Seafarers. Architect and painter Ian Marshall is a fellow of the American Society of Marine Artists, and his work has been exhibited at military and maritime museums in the United States and Great Britain. He is also the author of four books of paintings. A native of Scotland, he now lives on Mount Desert Island, Maine.

Giant Amphibian. Tim Wright is a writer and photographer based in Richmond, Virginia.

Chalk's Ocean Airways. Henry Scammell's first story for *Air & Space*, which ran in the premiere issue (Apr./May 1986), was on Pan Am's *China Clipper.*

Caroline Sheen is the photography/illustrations editor at *Air & Space.*

Will the Air Force Finally Get a Spaceplane? Ben Iannotta writes frequently about space and technology subjects from Summerland Key, Florida.

Winner Take All. Evan Hadingham is the senior science editor of the PBS series "NOVA." He is the author of *Lines to the Mountain Gods* and other popular science books and articles.

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(Signed) David R. Kefford General Manager

CALENDAR

December 7

"Pearl Harbor: Day of Infamy" seminar. The program ends with a flight demonstration of a World War II Mitsubishi A6M5 Zero fighter. Planes of Fame Air Museum, World War II Cal-Aero Field, Chino, CA, (909) 597-3722.

"Subchasers: A Remembrance of War" seminar. Listen to the stories of U.S. Navy pilots who hunted Japanese submarines in the Pacific during World War II. American Airpower Heritage Museum, Commemorative Air Force Headquarters, Midland International Airport, TX, (915) 563-1000.

December 14

First Flight Celebration. Mark the 99th year of the first manned, powered, controlled flight, made by the Wright brothers on December 17, 1903. Family-oriented hands-on activities with reproductions of Wright aircraft, including kites, gliders, and the 1903 *Flyer.* Virginia Aviation Museum, Richmond International Airport, VA, (804) 236-3622.

December 21 & January 18

Experimental Aircraft Association Chapter 908 Fly-In Pancake Breakfast. St. Lucie County Airport, Fort Pierce, FL, (772) 464-0538.

January 16–March 31

"Century of Flight" Aviation Art Exhibit. Paintings by Keith Ferris, featuring military aviation subjects with an emphasis on the U.S. Air Force. U.S. Air Force Museum, Dayton, OH, (937) 255-4704.

Organizations wishing to have events published in Calendar should fax press releases two months in advance to (202) 275-1886 or mail them to Calendar, Air & Space/Smithsonian, MRC 951, PO Box 37012, Washington, DC 20013-7012.

ON THE WEB SITE

www.airspacemag.com

With the publication of each issue, we post on the *Air & Space* Web site information, diagrams, photographs, and stories that provide background for or supplement the features in the magazine. If you enjoyed reading "Chalk's Ocean Airways," visit the Web site for a list of other companies offering seaplane service in the United States. If you'd like to see more of the Corsairs pictured in "CorsairFest," go to the Web site for a QTVR panorama of the aircraft and their owners. And remember to keep checking the *Air & Space* Web site for news of the centennial of flight celebrations that will be continuing throughout 2003.

ERIC LONG

100 YEARS

of aviation's greatest moments

In the next issue:
A special keepsake for flight's centennial year. We chronicle aviation's progress, from December 17, 1903, to the present:
- flights that made history,
- the most illustrious pilots who ever flew,
- technological breakthroughs,
- a timeline of milestones, records, events, and circumstances that turned aviation into a behemoth global industry,
- the wrong turns that led some aircraft designers off the path of advancing technology,
- and an appraisal of how the airplane changed the world.

PLUS ***Meet the Wright Brothers***
Insights from Tom Crouch, author of *The Bishop's Boys*, and the biographer whom the Wrights' descendants call "our family Boswell."

***Follow the* Flyer**
From those first tentative seconds at Kitty Hawk, through the feud between Orville Wright and the Smithsonian Institution, to the aircraft's 1948 return from England to the National Air Museum, curator Peter Jakab recounts the history of the artifact that started it all.

Learn to Fly It!
In our exclusive "How Things Work" series, we put you in the hip cradle and show you how to wing-warp your way through a flight in the first airplane.

Hear from History's Witnesses
In October 1909, when Teddy Roosevelt was in the White House and Victrolas were all the rage, one million New Yorkers saw Wilbur Wright on his 20-mile round-trip flight between Governor's Island and Grant's Tomb. Their commentary and that from other public flying exhibitions capture the exhilaration of an age.

AND ***Where will you be in 2003?***
An *Air & Space/ Smithsonian* Guide to centennial events and activities.

NASA DRYDEN

Supersonic transports like the Russian Tu-144L may have been a detour from the path of progress begun by the Wright Flyer *(above) in 1903.*

The Captain and the Showgirl

The National Aviation Club, an affiliate of the National Aeronautic Association, chose two winners for the annual Katherine and Marjorie Stinson Award for Achievement this year: Captain Beverley Bass of American Airlines, and aerobatic performer Patty Wagstaff.

Since 1977, the NAC has issued the Stinson Award to honor "a living woman for an outstanding and enduring contribution, a meritorious flight, or a singular technical development in the field of aviation, aeronautics, space, or related sciences." The award's namesakes, Katherine and Marjorie Stinson, were sisters in a flying family that gained fame in the early 1900s for its aeronautical achievements, including exhibition flying (Katherine), flight instruction (Marjorie), and aircraft construction (brother Eddie). Katherine and Marjorie were among the first women to earn pilot licenses in the United States.

Captain Beverley Bass

Carrying on the Stinson spirit, Beverley Bass, the third female pilot hired by American Airlines, has accumulated a number of her own firsts during her 26 years on the flight deck. She was the first female pilot at American to fly a line trip as a copilot on a Boeing 727 and a McDonnell Douglas MD-80, the first to fly as a 727 captain, the first to fly as a 727 captain with an all-female crew, and the first to become a Check Airman. In addition, she was the first woman in the United States to qualify as captain on a Boeing 767 and the world's first female 777 captain.

Bass' first flying job was less than auspicious: "I flew bodies in a Bonanza for a mortician," she says. But that assignment led to others, positioning her for the flight deck when American decided to open its cockpits to women in the 1970s.

Patty Wagstaff is a one-woman industry in the aviation community, performing low-level aerobatics at airshows, staging aviation stunts in films and television shows, demonstrating aircraft for manufacturers, and training pilots. She is the first woman to become a U.S. National Aerobatic Champion, a title she has won three times. On six occasions, she has flown with the U.S. Aerobatic Team in international competitions, and was the top U.S. finisher three times.

Patty Wagstaff

Wagstaff learned to fly in a Cessna 185 floatplane in Alaska in 1979 and has since earned her commercial, instrument, seaplane, commercial helicopter, and flight instructor ratings. She credits her father, a now-retired Japan Airlines pilot, with setting her course. "He took me up when I was a kid and put me in the left seat, letting me fly the big stuff, which in those days were DC-6s and -7s," she remembers.

Today Wagstaff flies a German-built Extra 300S. She donated her previous aircraft, an Extra 260, to the National Air and Space Museum in 1994.

—Stuart Nixon

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org or call (703) 527-0226.

LOGBOOK

Awards

The Elder Statesman of Aviation Award was established in 1954 to honor people who over a period of years have made significant contributions to aeronautics. The 2002 winners are research pilot and air racer Anne Bridge Baddour; Grumman Gulfstream I engineer Charles N. Coppi; Federal Aviation Administration examiner Verne Jobst, also a longtime director of the Experimental Aircraft Association's annual Oshkosh, Wisconsin fly-in; space artist Robert T. McCall; Washington, D.C. Airports Task Force president Leo J. Schefer; and the one-man general aviation support band and 50-year Cessna dealer Hartley A. (Hap) Westbrook.

Lieutenant General Thomas H. Miller, U.S. Marine Corps (Ret.), who is credited with promoting development of helicopters and vertical-takeoff fixed-wing aircraft, was selected by the NAA and the National Aviation Club to receive the 2002 Cliff Henderson Award for Achievement.

The 2001 Clarence M. Mackay Trophy was awarded to the crew of KNIFE 04, Air Force 20th Special Operations Squadron, for the rescue of the crew of a sister helicopter, a Sikorsky MH-53M, that crashed on a mountain in bad weather during a rescue mission in Afghanistan in November 2001. The NAA and the Air Force said the crew "distinguished themselves by extraordinary acts of valor and heroism."

Call for Nominations

Nominations will be accepted for the 2003 Katharine Wright Memorial Award from January 1 through March 31, 2003. It is awarded annually to a woman who has supported her husband in aerospace and thus was instrumental in his success, or contributed to the advancement of the art, sport, and science of aviation and spaceflight over an extended period.